EPA/ROD/R04-00/073
2000

EPA Superfund
Record of Decision:

US NASA MARSHALL SPACE FLIGHT CENTER
EPA ID: AL1800013863
OU 09
HUNTSVILLE, AL
09/19/2000

UNITED STATED ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8980
SEP 19 2000

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

4WD-FFB

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Art Stephenson, Director
DA01/A.G. Stephenson
Building 4200
Marshall SFC, AL 35812

Subj: Operable Unit 9 (OU-9) Record of Decision, Marshall SFC (MSFC) National Priority List (NPL) Site, AL
EPA ID# AL1800013863

Dear Mr. Stephenson:

The U.S. Environmental Protection Agency (EPA) Region 4 has reviewed the above subject record of decision document and concurs with No Further Response Action at Operable Unit-9 (OU-9). This remedy is supported by the previously completed Resource Conservation and Recovery Act (RCRA) closure certification and the findings of the *MSFC OU-9 Remedial Investigation and Risk Assessment Report.* Based on the information provided, the remedy of No Further Action is protective of human health and the environment.

The EPA appreciates the coordination efforts of Marshall SFC and the level of effort that was put forth in the documents leading to this decision. The EPA looks forward to continuing the exemplary working relationship with Marshall SFC as we move toward a final cleanup of the NPL site.

Sincerely,

Richard D. Green
Director
Waste Management Division

Memo

To: Whom It May Concern
From: Lucille Bailey, Information Specialist
(contractor for Superfund Docket)
Subject: US NASA Marshall Space Center, OU 9

These few pages were sent to the Superfund Docket, we can only assume they are meant to go along with the May 2000 ROD. One says Final and the other says Draft-Final. You guys are the professionals so I'll leave it up to you. The other ROD (May 2000) you should have received.

Operable Unit 9 (OU-9)
Record of Decision

Final

National Aeronautics and Space Administration
George C. Marshall Space Flight Center

Huntsville, Alabama
EPA ID# AL 1800013863

September 2000

Operable Unit 9 (OU-9)
Record of Decision
Final

National Aeronautics and Space Administration
George C. Marshall Space Flight Center

Huntsville, Alabama
EPA ID# AL 1800013863

September 2000

National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Reply to
Attn of. AD10/42-00

May 12 2000

TO: EPA/Jim Barksdale
ADEM/Tom Birks

FROM: AD10/Allen Elliott

SUBJECT: Draft-Final OU-9 Record of Decision

Enclosed are copies of the Draft-Final OU-9 Record of Decision which has been signed by MSFC. Two copies are being sent to Mr. Barksdale, three copies to Mr. Birks, two copies to Hugh Vick/Gannett Fleming, and one copy to Emily Olds/Gannett Fleming.

Please provide your concurrence on this document by July 12, 2000.

If you have any questions about this transmittal, please call me at (256) 544-0662.

Allen Elliot
Environmental Engineering
and Management Department

Enclosure

cc:
AD10\File Copy
CH2M Hill/Nannette Woods
CH2M Hill/Alan Bollinger
Gannett Fleming/Hugh Vick
Gannett Fleming/Emily Olds

Operable Unit 9 (OU-9)
Record of Decision

Draft-Final

National Aeronautics and Space Administration
George C. Marshall Space Flight Center

Huntsville, Alabama
EPA ID# AL 1800013863

May 2000

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Acronyms

ADEM	Alabama Department of Environmental Management
AWQC	Ambient water quality criteria
bgs	Below ground surface
CDI	Chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COPC	Chemical of potential concern
DA	Department of the Army
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
FR	*Federal Register*
ft	Feet
ft^2	Square feet
GWP	Groundwater protection criteria
HI	Hazard index
HSWA	Hazardous and Solid Waste Amendments
IWTB	Industrial Wastewater Treatment basin
IWTF	Industrial Wastewater Treatment Facility
MCL	Maximum contaminant level
mg/kg	Milligram(s) per kilogram
mg/L	Milligram(s) per Liter
mgd	Million gallons per day
MOA	Memorandum of agreement
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCP	National Contingency Plan
NFA	No further action
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	Operations and maintenance
OU	Operable unit
PA/SI	Preliminary assessment/site investigation
PVC	Polyvinyl chloride
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RI/FS	Remedial investigation /feasibility study
RFI	RCRA Facility Investigation
RSA	U.S. Army Redstone Arsenal
SARA	Superfund Amendments and Reauthorization Act of 1986
SMP	Site Management Plan

SSL	Soil screening level
SWMU	Solid waste management unit
TCL/TAL	Target compound list/target analyte list
UST	Underground storage tank
VSI	Visual site inspection
WNWR	Wheeler National Wildlife Refuge

SECTION 1

Declaration

1.1 Site Names and Locations

Operable Unit 9 (OU-9): Former Industrial Waste Treatment Facility (IWTF)
Marshall Space Flight Center (MSFC)
National Aeronautics and Space Administration (NASA)
Huntsville, Alabama

TABLE 1-1
OU-9: Former lWTF
OU-9 *Record of Decision*

Site No.	Site Name
MSFC-044	Industrial Waste Treatment Basin
MSFC-045	Concentrate Receiving Tank
MSFC-046	Concentrate Transfer Tank
MSFC-047	Hydrostatic Dump Lagoon
MSFC-048	Mix Tank
MSFO-049	East Ultimate Lagoon
MSFC-050	West Ultimate Lagoon
MSFC-A	Caustic Storage Tank

1.2 Statement of Basis and Purpose

This decision document presents the selected remedial action for the soils and groundwater at the former IWTF at MSFC, Huntsville, Alabama, developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Oil and Hazardous Pollution Contingency Plan (NCP).

This decision is based on the administrative record for these sites. MSFC has obtained concurrence from the Alabama Department of Environmental Management (ADEM) and the U.S. Environmental Protection Agency (EPA) regarding this decision.

MSFC is the lead agency for the remedial investigation/ feasibility study (RI/FS) process for the sites. EPA Region IV and ADEM are the supporting regulatory agencies for the sites. In accordance with Title 40 *Code of Federal Regulations* (CFR) 300.430, the regulatory agencies have provided input during this process. Although the regulatory agencies are not signatories of the document, the involved agencies have concurred with the no further action (NFA) recommendation.

1.3 Description of the Selected Remedy

Future remedial actions to the soils and groundwater at the OU-9 sites are not necessary for the protection of human health or the environment, based on an analysis of available and pertinent information for the sites as documented in the *MSFC OU-9 Remedial Investigation Report Final* (NASA, August 1999).

This report also included a risk assessment for the groundwater associated with the OU-9 sites. No further investigation of the soils, remedial action to the soils, investigation of the groundwater, or monitoring of the groundwater are necessary to ensure the protection of human health and the environment based on the data evaluated for these sites.

No additional sampling or monitoring of the soils or groundwater will be necessary under CERCLA or the Resource Conservation and Recovery Act (RCRA) because the conditions at the sites are protective of human health and the environment. The selected remedial alternative is therefore no further action, and the sites need not be modified nor undergo further sampling, investigation, or remediation.

1.4 Statutory Determinations

The selected remedy of "No Further Action" is protective of human health and the environment and complies with federal and state requirements that are legally applicable or relevant and appropriate.

No imminent or substantial threats to human health or the environment were found for the soils or groundwater at the referenced sites. Therefore, no remedial action is necessary to ensure the protection of human health and the environment. A 5-year review under CERCLA will not be necessary for these sites.

Sheila S. Cloud
Director
Center Operations Directorate

5/8/00
Date

SECTION 2

Decision Summary

2.1 Site Location and Description

MSFC is located in north-central Alabama (Figure 2-1) on approximately 1,840 acres of property within the boundaries of Redstone Arsenal (RSA). The irregularly shaped property is approximately 3 miles long on its north-south axis and 2 miles wide on its east-west axis. Most of the property adjacent to MSFC is under the primary control of the Department of the Army (DA). A substantial portion of RSA, including most of the lands to the south and west of MSFC, belongs to the Wheeler National Wildlife Refuge (WNWR). Only a small portion of the WNWR extends onto property controlled by MSFC.

The City of Madison is approximately 3 miles northwest of MSFC, the City of Huntsville is approximately 3½ miles northeast of MSFC, and the town of Triana is approximately 3½ miles southwest of MSFC, as shown in Figure 2-1.

OU-9 is comprised of eight solid waste management units (SWMUs) at the former IWTF. The location of OU-9 is shown in Figure 2-2.

2.2 Site History and Enforcement Activities

MSFC is a large-quantity generator of hazardous wastes and operates <90-day storage areas in accordance with the RCRA. MSFC also maintains interim status post-closure care under RCRA for three former surface impoundments (MSFC-044, 049 and 050) associated with the past treatment of metal plating wastes. MSFC's EPA identification number for manifesting hazardous waste is AL1800013863.

In 1985, NASA undertook initial environmental compliance audits of its facilities in response to CERCLA legislation. The initial audit identified five potential CERCLA sites at MSFC. A second audit documented in the *Sampling and Analysis Plan: Preliminary Assessment of CERCLA Candidate Sites* (June 1988) identified 30 sites of possible environmental significance.

The *Preliminary Assessment of CERCLA Candidate Sites and Related Sites of Possible Environmental Significance* (February 1989) included a preliminary assessment/site investigation (PA/Sl) of the 30 CERCLA candidate sites, including sample collection at 19 of the sites.

EPA performed a visual site inspection (VSI) in June 1989, which formed the basis of the *Interim RCRA Facility Assessment of the Marshall Space Flight Center* (July 1989). This assessment used the results of NASA's PA and identified 77 sites of possible environmental significance.

RSA performed a RCRA Facility Assessment (RFA) to evaluate all of the sites of potential environmental significance on RSA property, as documented in the *Identification and Evaluation of Potential Solid Waste Management Units and Areas of Concern* (February 1991).

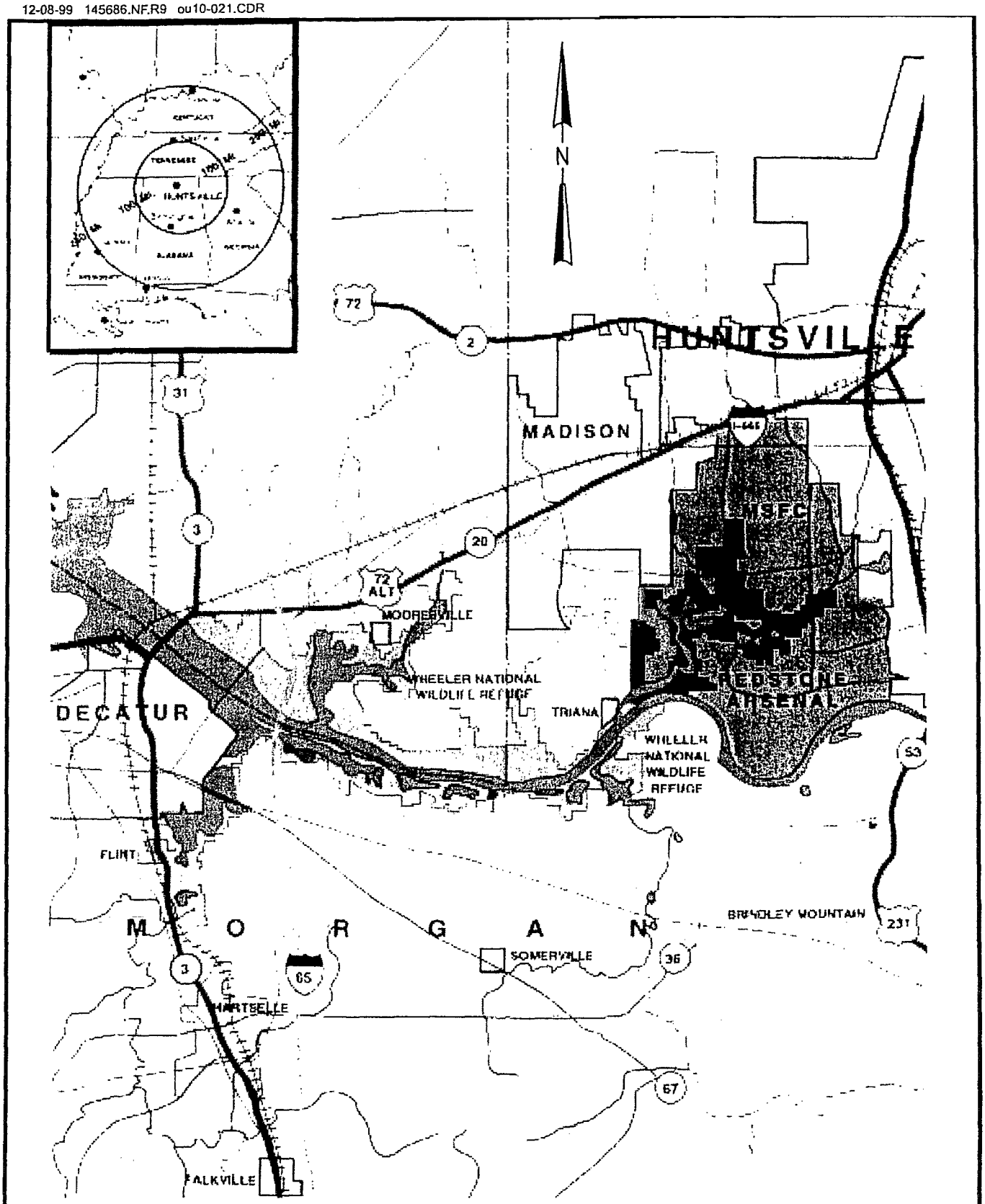

FIGURE 2-1
SITE LOCATION MAP
NASA - Marshall Space Flight Center
OU-9 Record of Decision

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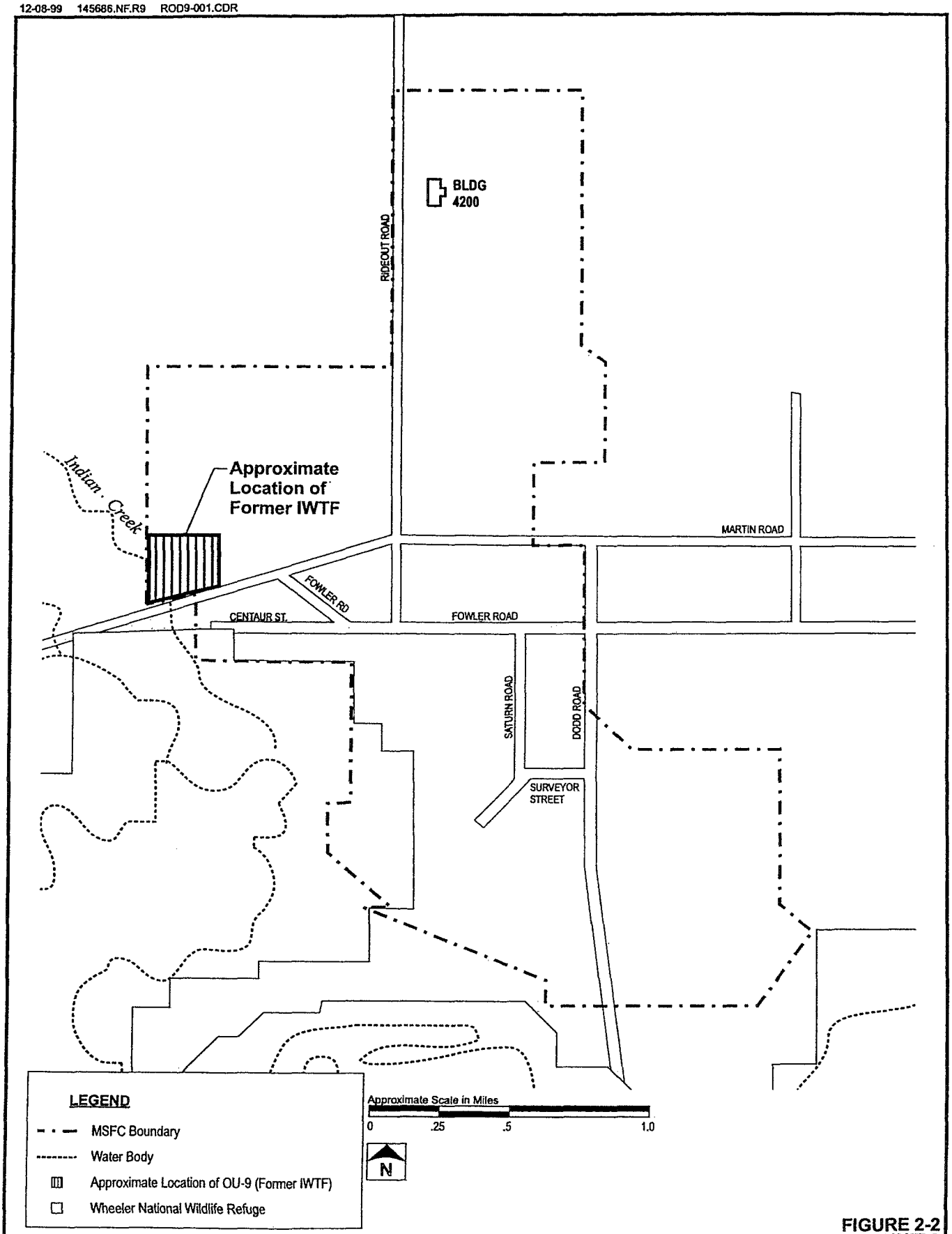

FIGURE 2-2
LOCATION OF OPERABLE UNIT 9
FORMER INDUSTRIAL WASTEWATER TREATMENT FACILITY
NASA - Marshall Space Flight Center
OU-9 Record of Decision

CH2MHILL

This RFA identified an additional 11 sites requiring investigation. NASA identified 7 more sites requiring further investigation, bringing the total number of sites to be addressed to 95. A memorandum of agreement (MOA) between NASA and the DA transferred 13 of these sites to the responsibility of the Army. In addition, 15 sites that were believed to have had no effect on the environment were removed by EPA from consideration, which reduced the total number of sites to be addressed by MSFC to 67. Eight of the MSFC sites have been assigned to OU-9.

Three sites within OU-9 (MSFC-044,049, and 050) were dosed under RCRA and certified in January 1990. This closure is described in the *Post-Closure Permit Application for the Ultimate Lagoons and IWTB* (1988). Post-closure inspection and maintenance activities were required under the RCRA closure.

NASA submitted a Part B RCRA permit application for post-closure operations at the former IWTF on August 1, 1991, to EPA and ADEM. NASA was awaiting permit application approval and subsequent issuance of the permit and its associated Hazardous and Solid Waste Amendments (HSWA) RCRA Facility Investigation (RFI) requirements when NASA was notified of its incorporation onto the National Priorities List (NPL) under the CERCLA program. EPA added RSA (U.S. Army/NASA) to the NPL by publication in the *Federal Register* (FR), 59 FR 27989, on May 31, 1994. MSFC is included in the listing of RSA on the NPL.

Soil samples were collected at the remaining five OU-9 sites (MSFC-045, 046, 047, 048, and A) in May 1996 as part of the CERCLA RI process. Subsequently, ADEM agreed that if additional sampling results demonstrated no risk to human health or the environment at the three RCRA closed sites (MSFC-044, 049, and 050) these sites could be approved for NFA under CERCLA. Since the RCRA program has deferred their authority to the CERCLA program, the acceptance of the NFA proposal through the CERCLA program would also apply to the RCRA program. A soils investigation at the three RCRA-closed sites (MSFC-044, 049, and 050) was conducted in May 1997 to provide data for confirmation of no further action for these sites. A residential human health risk assessment was also conducted for the soils and the groundwater beneath the OU-9 sites to support the no further action alternative.

The *MSFC OU-9 Remedial Investigation Report* was prepared in August 1999. One of the intents of the report was to document the NFA recommendation at the 8 sites within OU-9. After completion of the site inspection report, the *Proposed Plan for MSFC OU-9 Sites* (NASA, May 1999) was prepared. The Proposed Plan contains a summary of the NFA recommendation for OU-9.

2.3 Highlights of Community Participation

MSFC, EPA, and ADEM have made significant efforts to inform the public and to provide input regarding activities associated with the site. MSFC has been working with the community since its listing as an NPL site in 1994. As part of its community outreach efforts, MSFC held a public information meeting about the NFA recommendation for the OU-9 sites. The public information meeting was held on September 13, 1999, and was announced in the *Huntsville Times*. The meeting consisted of a poster session during which MSFC staff were available to answer questions from the public.

Information sessions were held for MSFC employees as a poster session and a presentation. Notices of the employee information sessions were announced in the MSFC newsletter, *The Marshall Star*, and daily announcement, *The Daily Planet*.

Information repositories were established for MSFC at the following five locations:

- MSFC, Alabama
- RSA, Alabama
- Huntsvilie /Madison County Public Library, Huntsville, Alabama
- Triana Public Library, Triana, Alabama
- Madison Branch Huntsville/Madison County Public Library, Madison, Alabama

The specific locations and contacts for these repositories are presented in Table 2-1.

TABLE 2-1
Information Repository Locations
OU-9 Record of Decision

NASA Public Inquiries Office	
MSFC/CO30	
MSFC, AL 35812	
Contact:	Ms. Rosa Kilpatrick
	256/544-0042
Hours:	M-F 8:00 a.m. to 4:30 p.m.
Redstone Scientific Information Center	
Building 4484	
Redstone Arsenal, AL 35989	
Contact:	Ms. Jean Bannister, Asst. Director
	256/876-9309
Hours:	M 11:00 a.m. - 4:00 P.M.
	T-F 8:00 a.m. - 7:00 p.m.
Huntsville/Madison County Public Library	
915 Monroe Street	
Huntsville, AL 35801	
Contact:	Mr. David Lilley
	256/532-5975
Hours:	M-Th 9:00 a.m. - 9:00 p.m.
	F, Sat 9:00 a.m. - 5:00 p.m.
	Sun 1:00 p.m. - 5:00 p.m.
Triana Public Library	
280 Zierdt Road	
Triana, AL 35758	
Contact:	Ms. Myrtle Benford
	256/772-3677
Hours:	M-Th 3:30 - 8:30 p.m.
	Sat 10:00 a.m. - 1:00 p.m.
Madison Branch Huntsville/Madison County Library	
181 Hughes Road	
Madison, AL 35758	
Contact:	Ms. Janelle Moritz
	256/461-0046
Hours:	M,W, 9:00 a.m. - 6:00 p.m.
	T, Th 9:00 a.m. - 8:00 p.m.
	F, Sat 9:00 a.m.- 5:00 p.m.

The *Proposed Plan for MSFC Surface Media OU-9 Sites* (NASA, May 1999) was placed into the information repositories and Administrative Record for the site. The public was encouraged to review the Proposed Plan, along with other related sources of information, including the *MSFC OU-9 Remedial Investigation Report* (NASA, August 1999). Related documents generated from CERCLA activities at the MSFC sites are listed in the reference section (Section 5). The public comment period was September 6 to October 5, 1999.

2.4 Scope and Role of Operable Units

CERCLA sites within MSFC have been grouped into 11 different OUs because of the complexity of the MSFC facilitywide RI/FS. The OUs can be described as smaller, incremental actions toward comprehensively addressing the MSFC sitewide progression of work and were based on risks to human health and the environment; similarity of investigation activities, including approaches, analytical methods, and data gaps; similar remediation approach; geography or location within the MSFC facility; and the NASA mission. The development of these OU groupings is summarized in the MSFC *Site Management Plan* (SMP) (NASA, October 1998), which is available in the information repositories.

Sites at the former IWTF were grouped into OU-9. The site-specific decision summary for OU-9 is provided in Section 3.

SECTION 3

Site-specific Decision Summary for OU-9

A decision summary for each OU-9 site is presented in the following subsections. The intent of the decision summary is to provide an overview of the site-specific factors and analyses that led to the selection of the remedy for the site. Each site-specific decision summary describes the following:

- Site characteristics
- Summary of site risks
- Description of the no further action alternative

Table 3-1 lists the sites within OU-9. None of these sites are operational. Figure 3-1 is an overall site location map denoting the location of each OU-9 site.

TABLE 3-1
Status of OU-9 Confirmation Sampling Sites
OU-9 Record of Decision

Site	Description
MSFC-044	Industrial Waste Treatment Basin
MSFG-045	Concentrate Receiving Tank
MSFC-046	Transfer Tank
MSFC-047	Hydrostatic Dump Lagoon
MSFC-048	Mix Tank
MSFC-049	East Ultimate Lagoon
MSFC-050	West Ultimate Lagoon
MSFC-A	Caustic Storage Tank

Three sites within OU-9 (MSFC-044, 049, and 050) were closed under RCRA and the closure was certified in January 1990. This closure is described in the *Post-Closure Permit Application for the Ultimate Lagoons and IWTB* (1988). Post-closure inspection and maintenance activities were required under the RCRA closure.

Soils samples were collected at the remaining five sites (MSFC-045, 046, 047, 048, and A) in May 1996 as part of the CERCLA RI process. Subsequently, ADEM agreed that if additional sampling results demonstrated no risk to human health or the environment at the three RCRA closed sites (MSFC-044, 049, and 050) these sites could be approved for NFA under CERCLA. Since the RCRA program has deferred their authority to the CERCLA program, the acceptance of the NFA proposal through the CERCLA program would also apply to the RCRA program. A soils investigation at the three RCRA-closed sites (MSFC-044, 049, and 050) was conducted in May 1997 to provide data for confirmation of no further action for these sites. A residential human health risk assessment was also conducted for the soils and the groundwater beneath the OU-9 sites to support NFA for CERCLA, with protective limits that support clean closure under RCRA.

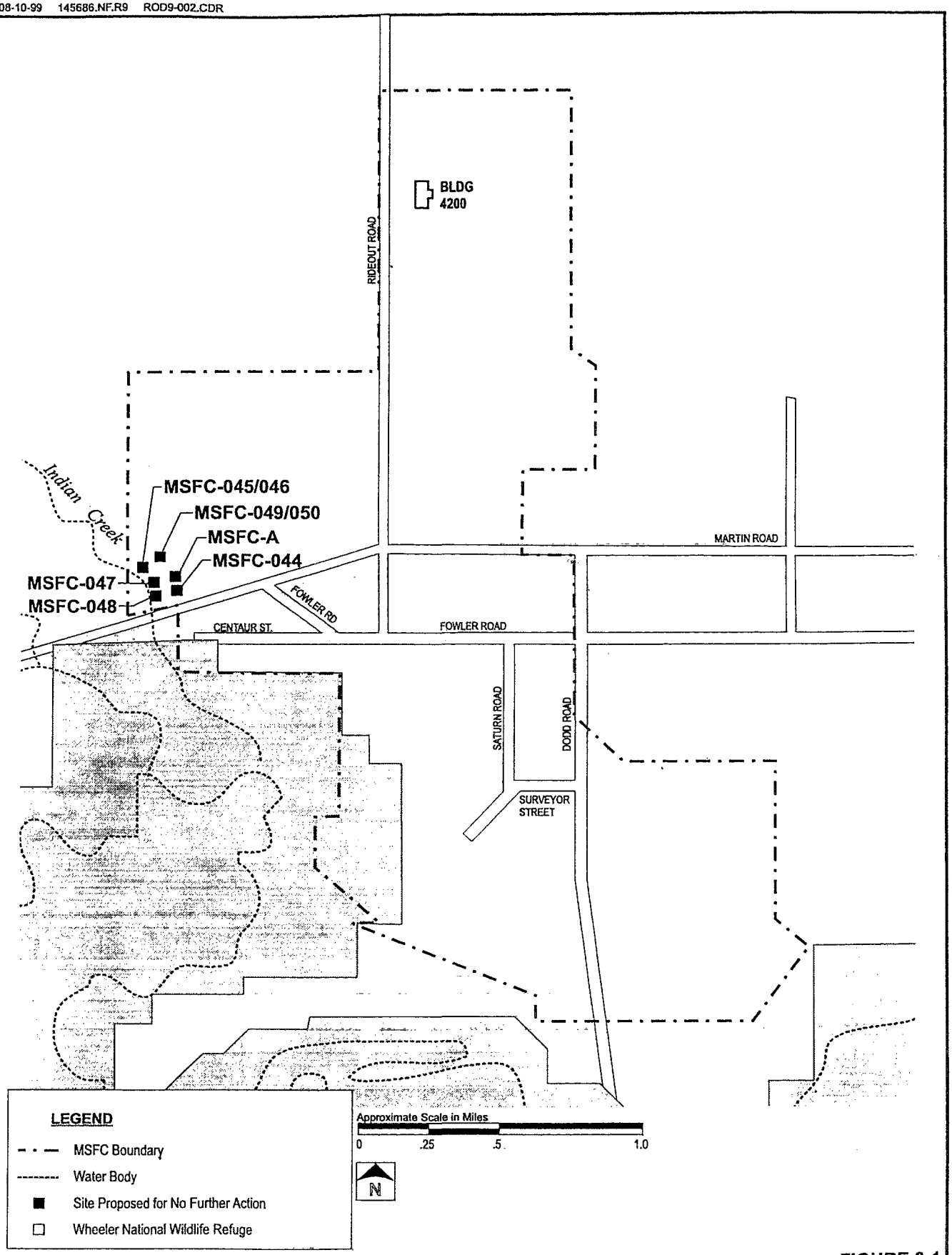

FIGURE 3-1
SITES WITHIN OPERABLE UNIT 9
NASA - Marshall Space Flight Center
OU-9 Record of Decision

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To facilitate understanding of the sampling results discussed for each site, a brief summary of the data evaluation process is provided in this subsection.

The data evaluation approach included a comparison to the direct contact values, cross media transfer values protective of groundwater, and naturally occurring levels for metals and inorganics. A set of site-specific background data collected from the confirmation sampling effort were compared with background concentrations, human health protection-based criteria (risk-based concentration [RBC]) and generic soil screening levels (SSLs).

Step 1—The site was evaluated for detected parameters. A site containing no detected parameters was proposed for NFA.

Step 2—The concentration of detected parameters at a site was compared to the RBCs to reflect incidental ingestion of soils and potential migration of chemicals to groundwater. Sites for which detected parameters were below both of these RBCs were proposed for NFA. In addition, a special case also results in NFA in the preliminary screening:

- If the exceedance occurred for a few (one or two) noncarcinogenic chemicals at the hazard index (HI) of 0.1, it indicates that the combined chemical concentrations would not exceed the target HI of 1.0. The site would then be recommended for NFA.

Step 3—The concentrations of detected parameters (that had levels above screening criteria) were compared to the background concentration levels detailed in the *Final Report of MSFC Background Sampling* (NASA, December 1997). If the maximum concentration of detected parameters was below twice the average background concentration levels, the site was proposed for NFA.

Step 4—A final evaluation of the data was done for sites where a detected parameter was above both the RBC and the background concentration levels. The concentrations relative to background, practical quantitation limits (PQLs), potential sampling artifacts, implications of biased sampling, frequency of detection, and the applicability of the residential direct exposure-based and the conservative cross media transfer assumptions-based SSLs to these sites was considered in the final NFA determination. A comparison of observed parameter concentrations to ecological receptor criteria was not deemed appropriate because exposure was incomplete. A qualitative evaluation of potential exposure pathways and ecological receptor occurrence was conducted by site.

Within the Ecological Risk Assessment, the analytical data were evaluated using a 'Tiered' process in which conservative screening values were used for the initial evaluation to identify those chemicals requiring further evaluation within a Tier II level ecological risk evaluation. The initial screening of the OU-9 sites showed that the OU-9 sites do not provide a natural setting that would provide a habitat for ecological receptors and a Tier II level ecological risk assessment was not warranted.

A summary of the confirmation sampling results and the associated risk assessment findings are provided, along with the OU-9 site descriptions, in the following subsections. Additional site characterization and risk assessment information may be found in the following reports:

- *Final Report of MSFC Background Sampling* (NASA, December 1997)
- *Draft Final MSFC Ecological Risk Assessment Report* (NASA, October 1998)

- MSFC OU-9 *Remedial Investigation Report Final* (NASA, August 1999)

3.1 MSFC-044¾ Industrial Waste Treatment Basin

3.1.1 Site Characteristics

The Industrial Waste Treatment Basin (IWTB) (MSFC-044) was operational from 1969 to 1989. The clay-lined basin was approximately 350 feet (ft) by 150 ft and 6 ft deep (52,500 square ft. [ft^2]). The basin contained three baffles that divided it into four approximately equal cells. The unit originally received clarified water from Building 4760, condensate from the steam evaporator, and flow from the industrial sewer. The IWTB served as an equalization basin in the industrial wastewater treatment system from 1985 to 1989. The flow during this time was approximately 0.15 million gallons per day (mgd). After the second phase of construction of the IWTF was completed (1985), the IWTB received only the flow from the industrial sewer. Sodium hydroxide was added to the wastewater to aid in metals precipitation. As a result, metal hydroxide sludges accumulated to a thickness of 6 to 8 inches in the bottom of the basin. The liquid from the basin was disposed of through a National Pollutant Discharge Elimination System (NPDES)-permitted outfall on the southwestern side of the basin. The sludges were drummed and disposed of at a designated disposal facility.

MSFC-044 (Figure 3-2) was closed in accordance with RCRA regulations and certified in January 1 990. This closure is described in the *Post-Closure Permit Application for the Ultimate Lagoons and IWTB* (1988).

Existing foundations and structures within the site, as well as the underground piping, were removed before backfilling. All standing water and sludges were removed and drummed for offsite disposal. Demolished material was broken into small pieces and placed in the lagoon as fill material. The remaining excavation was backfilled with a high clay content, low-permeability soil. A clay cap was placed over the backfill to provide a low-permeability barrier to infiltration. A french drain system was installed along the northern side of MSFC-044 to channel water westward, away from the surface impoundments.

The site was protected from erosion by grassing. A layer of topsoil was placed over the cap and seeded with common Bermuda grass seed. Lime, fertilizer, and mulch also were used to promote grass establishment.

Two samples collected from borings SB09-38 and SB09-48 were analyzed for the target compound list/target analyte list (TCL/TAL). The samples collected from the other 18 MSFC-044 borings were analyzed for the chemicals of potential concern (COPCs). Borings SB09-38 and SB09-48 were selected for TCL/TAL analysis because of the proximity of the borings to the former industrial sewer inlet and the former NPDES-permitted outfall.

3.1.2 Current and Potential Future Land and Resource Uses

As previously noted, MSFC-044, Industrial Waste Treatment Basin, has been closed under RCRA. Existing foundations and structures within the site, as well as the underground piping, were removed before backfilling. The site was protected from erosion by grassing. The site has been maintained in a grassy condition and is not used for any other purpose.

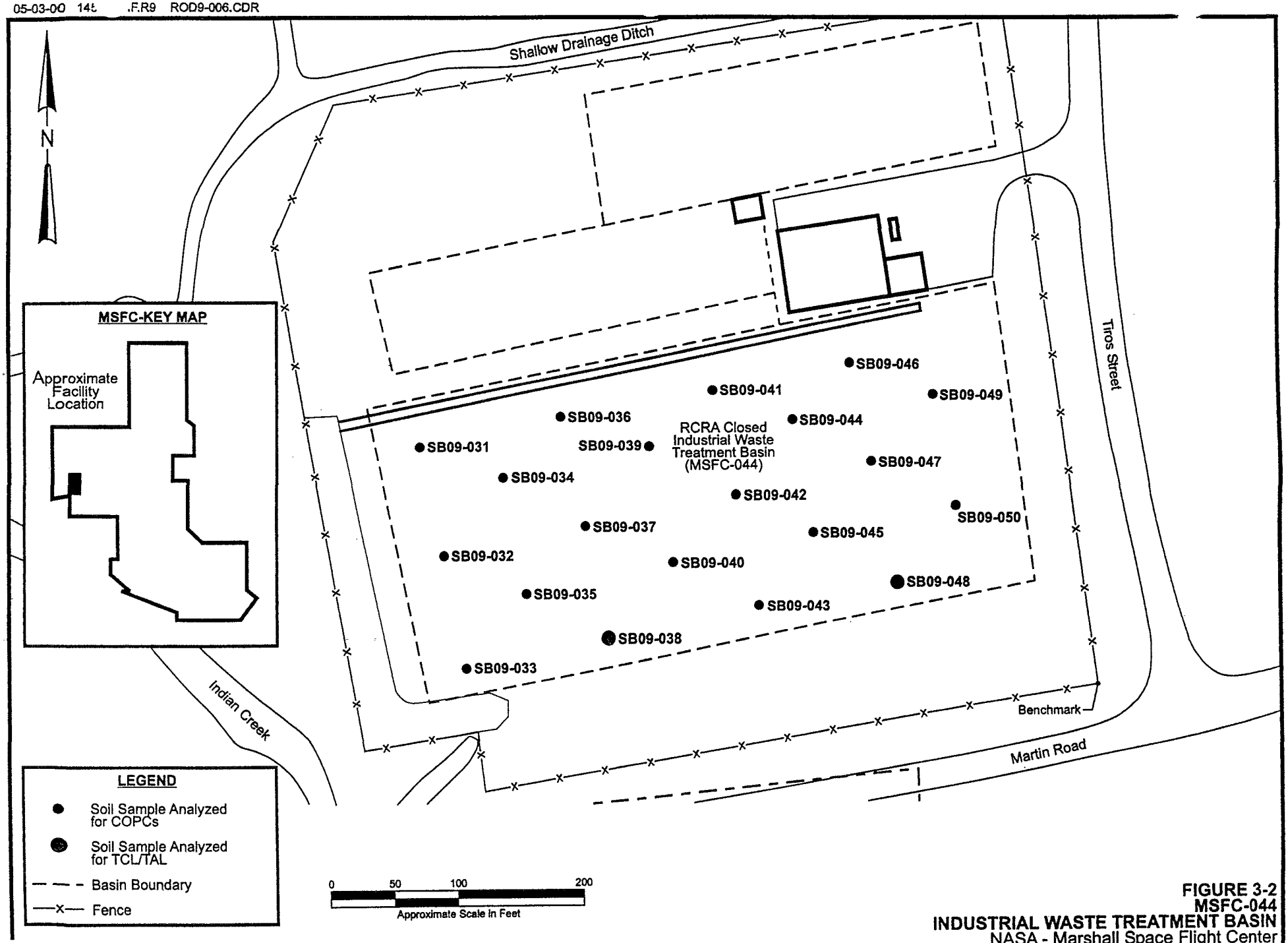

FIGURE 3-2
MSFC-044
INDUSTRIAL WASTE TREATMENT BASIN
NASA - Marshall Space Flight Center
OU-9 Record of Decision

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On March 15,1960, the Army granted irrevocable use and occupancy of the lands and facilities known as MSFC to NASA for a term of 99 years beginning on July 1, 1960, and ending on June 30, 2059. The adjacent and surrounding lands to the north and east of OU-9 are contained within the MSFC facility, are used for industrial purposes, and will continue to be used for industrial purposes in the future. The adjacent lands to the west are owned and occupied by RSA and are also designated for industrial purposes. The WNWR is south of OU-9, however this area of the refuge is designated as restricted access and is not readily accessible by the public.

Indian Creek and some small tributaries are west and south of OU-9. However, these areas have been designated as no fishing zones because of previous contamination from sources other than MSFC. No fishing signs have been posted in these areas. These areas are outside the MSFC property boundary, but within RSA, and access to the offsite public is restricted. In addition, most of the area along the Creek is inaccessible because of overgrowth and is not conducive for recreational use.

The groundwater beneath the site is not currently used as a drinking water source. The groundwater beneath this site does not pose any residential risk, however future use of the groundwater as a drinking water source is not anticipated.

3.1.3 Summary of Site Risks

In May 1998, one soil sample was collected at approximately 1 foot below the base of the unit into the native soil from each of the 20 borings at MSFC-044. The investigation covered the basin area (approximately 52,500 ft^2). The actual base of the closed unit was determined for sampling purposes by noting the depth within the boring at which fill soil changed to native material. All of the samples were collected above the water table.

Analytical data for the observed parameters are summarized in the decision tables in Appendix A. The sites and sample locations are shown in Figure 3-2.

Risk-based Concentrations and Background Comparisons for Soils. Because no organic constituents were detected above RBCs, only concentrations of naturally occurring metals warranted evaluation. Inorganic constituents exceeding the background concentration included arsenic, lead, manganese, mercury, and nickel. All of the exceedances were within an order of magnitude of the background concentration. There was only one exceedance each of lead, manganese, and mercury.

Soil Leaching to Groundwater Comparisons. The only chemicals exceeding screening values protective of groundwater were arsenic, lead, manganese, mercury, and nickel. All of the exceedances were within an order of magnitude of the SSL. There was only one exceedance each of lead manganese, and mercury. In addition, recent data from MSFC's groundwater monitoring program at the IWTF show that the mean concentrations detected for lead, manganese, and nickel were 5.03, 2.22, and 0.0419 milligrams per liter (mg/L). These values are below the maximum contaminant levels (MCLs) or RBCs for tap water. Mercury was not detected in the groundwater. No further investigation of this pathway is warranted.

Residential Risk Assessment. The residential risk assessment is detailed in Appendix B. The MSFC-044 data are from subsurface soils; there are no COPCs for the surface soil. Assumptions used for the subsurface soil exposure scenario are highly conservative because if

subsurface soils are excavated and become exposed, they are likely to have lower concentrations because of mixing. In addition, the subsurface soil does not pose any risk beyond that resulting from naturally occurring arsenic levels. Arsenic is detected at a maximum concentration of 19.2 milligrams per kilogram (mg/kg), which is similar to the background concentration for arsenic of 13.6 mg/kg. The exposure point concentration (EPC for arsenic (upper confidence level 95 percent) is 12.9 mg/kg, which is below background level. Therefore, the MSFC-044 potential risks are below the background risk levels. The overall site risks under the most conservative risk estimation scenario are within the acceptable limits and below the background levels. The site soils do not present a human health risk under existing conditions and potential future use based on the data evaluated for this site.

The site is not located over a regional groundwater contaminant plume. The groundwater was evaluated for human health risks using data generated from the RCRA monitoring program. Only iron and manganese were detected above both the background and a health-based concentration level. The human health risk assessment concluded that the groundwater beneath the OU-9 sites does not present significant risks based on the hazard indexes evaluated for iron and manganese. There were no carcinogenic chemicals detected above background levels in the groundwater.

The residential human health risk assessment concluded that the soil and groundwater at the site do not present human health risks under existing conditions and potential future use scenarios.

Ecological Risks. To have a completed exposure pathway to ecological receptors, the following elements need to be present:

- A source of exposure
- An exposure pathway
- A receptor

MSFC-044 was closed under RCRA and no COPCs have been identified. In addition, the sites do not have a natural setting that would provide habitat for ecological receptors. Exposure to ecological receptors is incomplete, given the lack of a natural setting in which ecological receptors would occur. MSFC-044 does not have an ecological receptor exposure potential based on the data evaluated for the site and, therefore, no further evaluation is warranted.

3.1.4 Description of the "No Further Action" Alternative

MSFC-044, Industrial Waste Treatment Basin, has been closed under RCRA. No further investigation or remedial action is necessary for the soil or groundwater at this site for the protection of human health or the environment, based on an analysis of available and pertinent information for MSFC-044 (IWTB). Therefore, the selected remedial alternative for the soil and groundwater at this site is NFA. This alternative will consist of leaving the site in its current condition. No additional sampling or monitoring of the soils or groundwater will be necessary because the conditions at the site are protective of human health and the environment.

No further post closure inspection or maintenance activities or groundwater monitoring will be required under RCRA as a result of the NFA alternative.

3.2 MSFC-045/046–Concentrate Receiving Tank and Transfer Tank

3.2.1 Site Characteristics

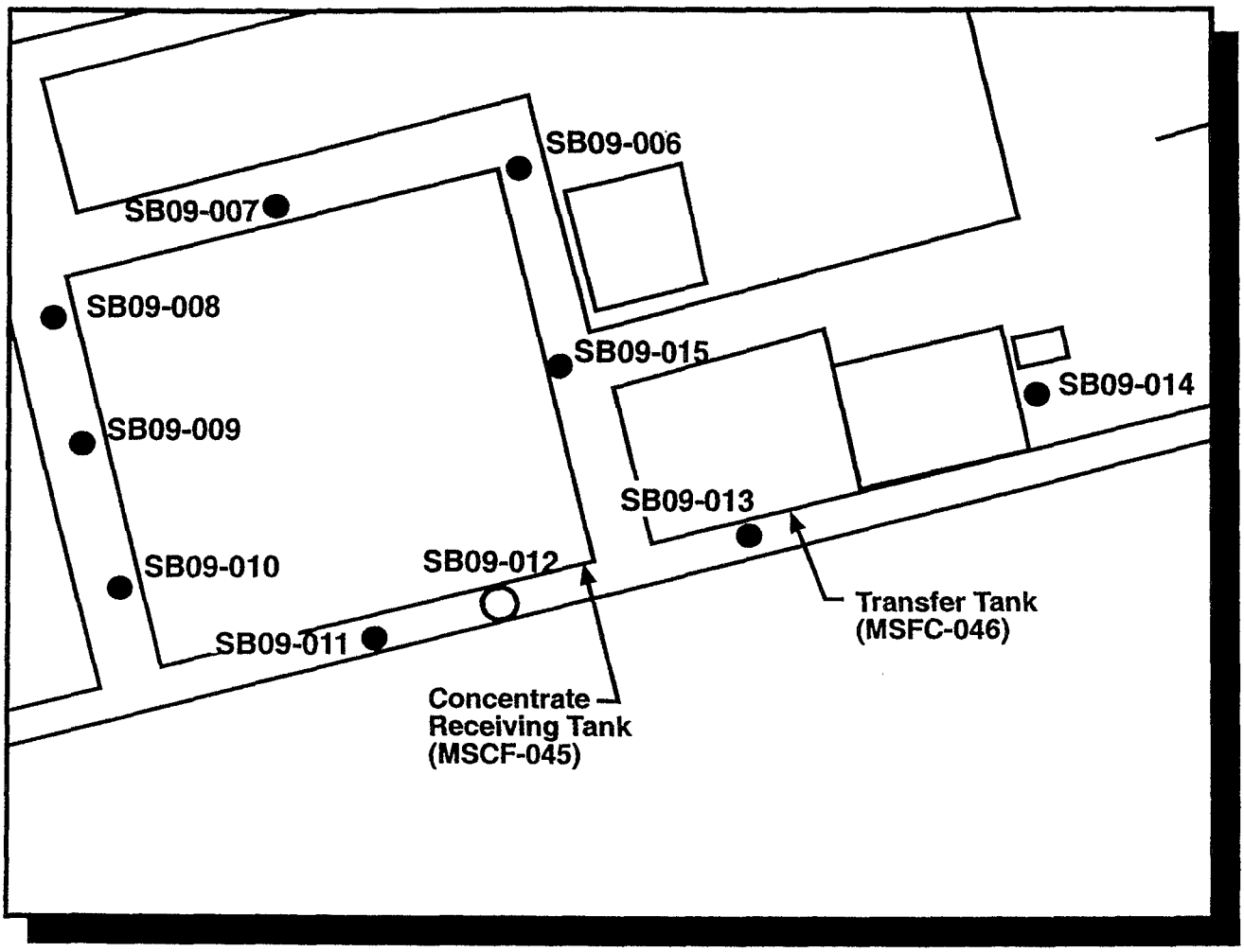
The Concentrate receiving tank (MSFC-045) was operational from 1969 to 1984. The unit is located in the southwestern part of the facility, north of the IWTB (MSFC-044). The unit is a tank approximately 64 ft by 85 ft and 4 to 8 ft deep. It is lined with polyvinyl chloride (PVC) liner and is supported on a concrete slab. The tank is covered by a roof that provides a 2-foot open space around the unit. The unit received flows from the Building 4760 plating baths, which consisted of pickling and plating liquors, drag-out, and dilute rinse waters. Waste-water was treated in this unit by neutralization and precipitation using sodium hydroxide from the caustic storage tank (MSFC-A). The metal hydroxide water slurry was thickened by a dewatering operation that included the use of a steam evaporator. The dewatered sludge was transferred to the ultimate lagoons (MSFC-049 and 050) and the condensate from the steam evaporator was discharged into the IWTB.

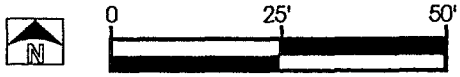
The transfer tank (MSFC-046) is a non-operational in-ground tank that was operational from 1969 to 1984. This concrete tank, located in the southwestern part of the facility and north of the IWTB (MSFC-044), is approximately 29 ft by 24 ft and 3 to 6 ft deep. This tank received the neutralized wastewater from the concrete receiving tank and transferred it to the evaporator building. Some metal hydroxide sludge accumulated in this tank. The resulting metal hydroxide sludge from the concentrate receiving tank (MSFC-045) and transfer tank was routed to the East and West Ultimate Lagoons (MSFC-049 and 050, respectively).

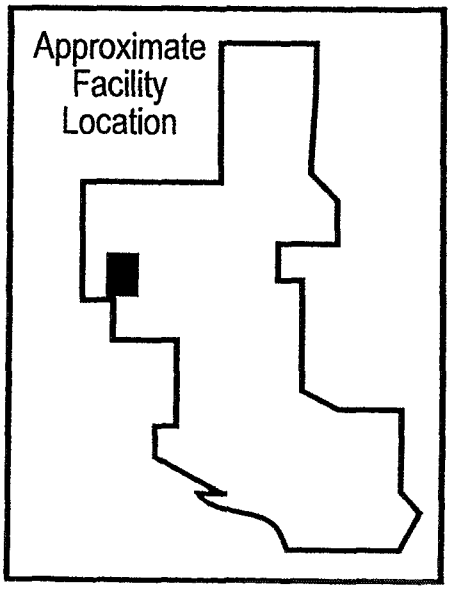
No previous sampling of these units is known to have occurred before the RI. Therefore, the RI included investigating the possibility of a contaminant release to the surrounding surface and subsurface soils. The wastewater stream received by the units contained metal plating waste from Building 4760. This wastewater stream consisted mainly of metals and cyanide; thus, the COPCs for the surrounding soils are metals (priority pollutant metals), cyanide, and hexavalent chromium. Groundwater contamination is not considered probable because one unit is lined with concrete and the other is PVC-lined. A review of existing documents does not show evidence that the units were cracked. Current air releases also are not considered probable because the tanks are no longer receiving waste.

MSFC-045 and MSFC-046 were investigated concurrently because the two units received the same wastewater stream and because of the proximity of the sites. The investigation covered approximately 11,300 ft^2. In May 1996, 10 soil borings were installed at the site approximately 5 ft from the concrete structures, as shown in Figure 3-3. A horizontal distance of 5 ft was selected because slug test data in the clay residuum collected at the IWTF (NASA, 1992) led to estimated permeabilities that would allow wastewater to migrate from the units at a rate of approximately 0.001 foot per day (foot/day).

These units have been in place for approximately 25 years. Assuming that waste or water has seeped from. the units over this entire time and that there has been no vertical migration,







MSFC-Key Map

LEGEND

- ● Soil Sample Analyzed for COPCs
- ○ Soil Sample Analyzed for TCL/TAL

FIGURE 3-3
MSFC-045/046
CONCENTRATE RECEIVING TANK AND TRANSFER TANK
NASA-Marshall Space Flight Center
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the horizontal seepage would extend approximately 9½ ft. The units were dosed 8 years ago, indicating that the horizontal seepage of any waste remaining in the unit when it was taken offline would have migrated approximately 3 ft from the units (assuming that there has been no vertical migration). An unknown extent of vertical migration has occurred, thereby diluting the concentrations of the waste at the outer migration point. Therefore, samples were collected closer to the units, but within the 3- to 9½-foot area of expected contamination. The distance of 5 ft was selected as a biased location for the sampling.

Two soil samples were collected from borings SB09-006 through SB09-015 (20 samples)–one from a depth of 0 to 12 inches and the second from a depth of approximately 1 foot below the base of the structures or above the groundwater table, whichever was encountered first.

Two samples collected from a southern boring (SB09-012) were analyzed for the TCL/TAL. The remaining 18 samples (9 borings) were analyzed for the COPCs.

The samples collected from the southern boring were selected for TCL/TAL analyses because the topography of the IWTF slopes south; therefore, surface spills would migrate south. The MSFC-045/046 data are from surface and subsurface soils.

3.2.2 Current and Potential Future Land and Resource Uses

As previously noted, MSFC-045/046, Concentrate Receiving Tank and Transfer Tank, are non-operational tanks located at the former IWTF. Wastes were removed from the tanks when the IWTF was taken out of service. The tanks have been left in place but are no longer in service.

As noted in Section 3.1.2, the Army has granted NASA an irrevocable lease of the MSFC facility through June 30, 2059. The adjacent and surrounding lands are contained within MSFC or RSA, are used for industrial purposes, and will continue to be used for industrial purposes in the future. The WNWR is to the south of OU-9, however this area of the refuge is designated as restricted access and is not readily accessible by the public.

Indian Creek and some small tributaries are west and south of OU-9. However, these areas have been designated as no fishing zones because of previous contamination from sources other than MSFC. No fishing signs have been posted in these areas. These areas are outside the MSFC property boundary, but within RSA, and access to the offsite public is restricted. In addition, most of the area along the Creek is inaccessible because of overgrowth and is not conducive for recreational use.

Groundwater beneath the site does not pose a residential risk, and is not currently used as a drinking water source. Future use of the groundwater as a drinking water source is not anticipated.

3.2.3 Summary of Site Risks

Analytical data for the observed parameters are summarized in the decision tables in Appendix A. The sites and sample locations are shown in Figure 3-3.

Risk-based Concentrations and Background Comparisons for Soils. Because no organic constituents were detected above RBCs, only concentrations of naturally occurring metals needed to be evaluated. Noncarcinogens exceeding the background concentration and the

RBC for ingestion included cadmium, manganese, and nickel in the samples collected from the surface. The maximum cadmium and manganese concentrations exceeded two times their average background value, but are within the same order of magnitude of this value. The average cadmium value detected during the sampling is similar to the RBC.

Direct exposure to the onsite industrial worker-based RBC value for nickel is 41,000 mg/kg at an HI value of 1.0, and 4,100 at an HI of 0.1. The site concentrations did not exceed these values.

Cadmium and nickel did not exceed the RBCs for residential exposures, as presented in the EPA Region III RBCs, indicating that a hazard quotient for this chemical below 1. The HI, which is the sum of the hazard quotients for all noncarcinogens detected at the site, did not exceed 1; therefore, the presence of multiple constituents does not suggest a risk at this site.

Soil Leaching to Groundwater Comparisons. Chemicals exceeding screening values protective of groundwater included acetone, barium, cadmium, and nickel. As noted in the data quality evaluation in the RI Report, the acetone detections probably are from incomplete drying of the isopropanol during decontamination procedures during the sampling event. Further evaluation of arsenic is not warranted. The concentrations detected of these other chemicals were within an order of magnitude of the respective SSLs. In addition, recent data from MSFC's groundwater monitoring program at the IWTF show that the mean concentration detected for barium was 0.0692 mg/L and nickel was 0.0419 mg/L. All of these values are below the MCLs or RBCs for tap water. Cadmium was not detected in the groundwater. The difference between these values is negligible. No further investigation of this pathway is warranted.

Residential Risk Assessment. The residential risk assessment is detailed in Appendix B. The MSFC-045/046 data are from subsurface soils; there are no COPCs for the surface soil. Assumptions used for the subsurface soil exposure scenario are unrealistic, because if subsurface soils are excavated and become exposed, they are likely to have lower concentrations because of mixing. The second important reason that these estimated risks are not considered important is because they are mainly from arsenic, which is naturally occurring in the site soils. The risks estimated at 2×10^{-5} are from arsenic detected in surface soil samples. The maximum observed arsenic concentration is 12 mg/kg, compared to a surface soil background value of 10.9 mg/kg. The EPC value, described in Appendix B, for arsenic is estimated at 9.51 mg/kg, which is below the background level. The total site risks therefore are below the background levels.

The site is not located over a regional groundwater contaminant plume. The groundwater was evaluated for human health risks using data generated from the RCRA monitoring program. Only iron and manganese were detected above both the background and a health-based concentration level. The human health risk assessment concluded that the groundwater beneath the OU-9 sites does not present significant risks based on the hazard indexes evaluated for iron and manganese. There were no carcinogenic chemicals detected above background levels in the groundwater.

The residential human health risk assessment concluded that the soil and groundwater at the site do not present human health risks under existing conditions and potential future use scenarios.

Ecological Risks. The potential source of exposure attributable to these sites is waste that may have saturated soils adjacent to the tanks. Ecological receptors are unlikely to be exposed to subsurface soils. Surface soils represent the most significant potential exposure medium. Analyses of shallow boring samples indicated the presence of inorganic constituents and some organic chemicals. The organic chemicals were detected at low concentrations, and several of these chemicals are unlikely to persist given their volatile characteristics. Of the list of inorganic constituents detected, only aluminum, cadmium, chromium, copper, cyanide, iron, manganese, nickel. and silver were above comparable background concentration levels. Aluminum and iron are common elements, while copper and manganese are essential elements. In addition, these constituents were not present at sufficient quantities to cause adverse effects on exposed receptors. The remaining constituents of chromium, cyanide, nickel, and silver are of concern if present at sufficient quantities to cause adverse effects on exposed receptors.

The concentrate receiving tank and transfer tank (MSFC-045, and 046) do not provide a natural setting that would provide a habitat for ecological receptors. The area outside these sites may provide some natural resources that ecological receptors could use. However, exposure to ecological receptors is incomplete, given the lack of a natural setting in which ecological receptors would occur. MSFC-045 and 046 do not, have an ecological receptor exposure potential, based on the data evaluated for this site and, therefore, no further evaluation is warranted.

3.2.4 Description of the "No Further Action" Alternative

MSFL-045/046, Concentrate Receiving Tank and Transfer Tank, are non-operational tanks located at the former IWTF. No further investigation or remedial action for the soils or groundwater is necessary for the protection of human health or the environment, based on an analysis of available sample results and pertinent information. Therefore, the selected remedial alternative for the soils and groundwater at OU-9 is NFA. No additional sampling or monitoring of the soils or groundwater will be necessary because the conditions at the site are protective of human health and the environment.

No further groundwater monitoring will be required under RCRA as a result of the NFA alternative.

3.3 MSFC-047¾ Hydrostatic Dump Lagoon

3.3.1 Site Characteristics

The hydrostatic dump lagoon (MSFC-047) is a non-operational, clay-lined settling lagoon. The unit is approximately 300 ft by 71 ft and 4 ft deep (2,130 ft^2). Rinse water and spray paint booth wastewater from Building 4760 were discharged to the mix tank, where the pH was adjusted before the contents were discharged into this unit. The water in the unit was allowed to evaporate and was not discharged to any receiving streams or other treatment units.

No previous sampling of this unit is known to have occurred before the RI. The RI included investigating the possibility of a contaminant release to the surrounding surface and subsurface soils. The wastewater stream received by the unit contained metal plating waste

from Building 4760. This wastewater stream consisted mainly of metals and cyanide; thus, the COPCs for the surrounding soils are metals, cyanide, and hexavalent chromium. Groundwater contamination is not considered probable because the unit is day-lined. Current air releases also are not considered probable because the lagoon is no longer receiving waste.

3.3.2 Current and Potential Future Land and Resource Uses

As previously noted, MSFC-047 is a clay-lined settling lagoon that is non-operational. Wastes were taken out of the unit when the IWTF was taken out of service. The unit was left in place but is no longer in service.

As noted in Section 3.1.2, the Army has granted NASA an irrevocable lease of the MSFC facility through June 30, 2059. The adjacent and surrounding lands are contained within MSFC or RSA, are used for industrial purposes, and will continue to be used for industrial purposes in the future. The WNWR is to the south of OU-9, however this area of the refuge is designated as restricted access and is not readily accessible by the public.

Indian Creek and some small tributaries are west and south of OU-9. However, these areas have been designated as no fishing zones because of previous contamination from sources other than MSFC. No fishing signs have been posted in these areas. These areas are outside the MSFC property boundary, but within RSA, and access to the offsite public is restricted. In addition, most of the area along the Creek is inaccessible because of overgrowth and is not conducive for recreational use.

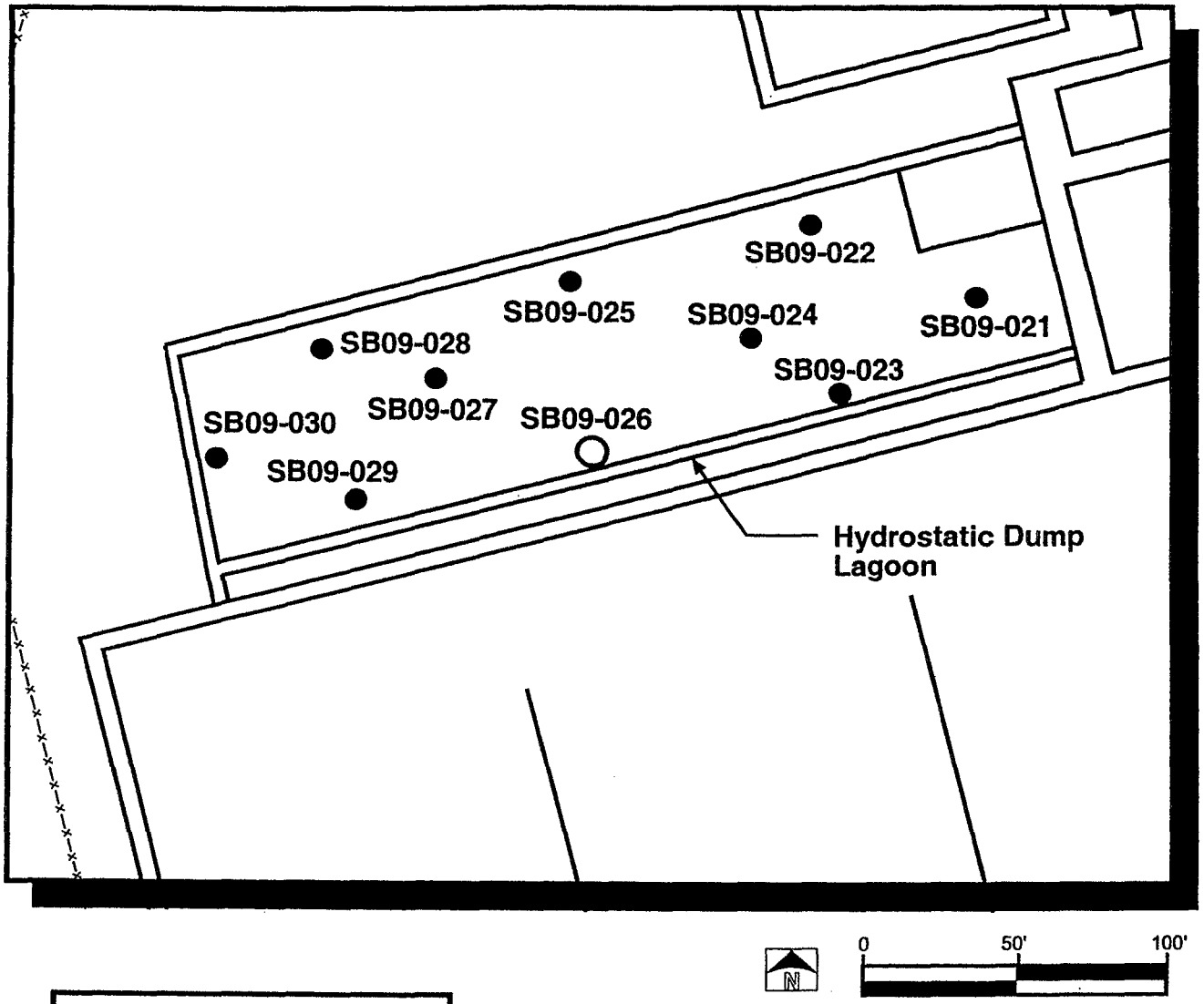
Groundwater beneath the site does not pose a residential risk, and is not currently used as a drinking water source. Future use of the groundwater as a drinking water source is not anticipated.

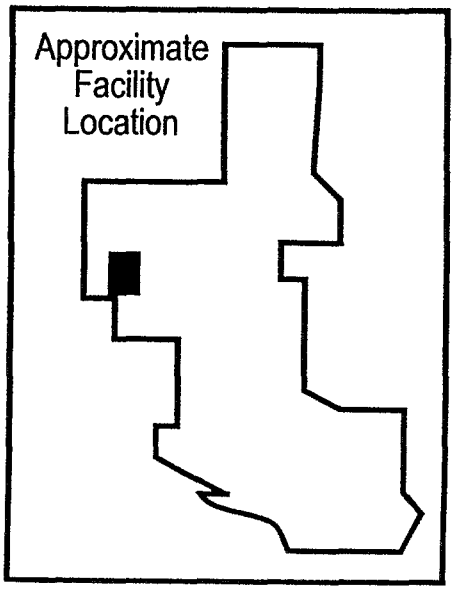
3.3.3 Summary of Site Risks

In May 1996, 10 soil borings were installed inside the lagoon (biased locations), as shown in Figure 3-4. Two soil samples were collected from borings SB09-021 through B09-030 (20 samples): one from a depth of 0 to 12 inches and the second from a depth immediately above the water table or 5 ft, whichever was encountered first. Nine of the borings (18 samples) were analyzed for the COPCs. Two samples from a centrally located boring (SB09-26) were analyzed for the TCL/TAL. Centrally located samples from the lagoon provided the most conservative sampling approach for TCL/TAL analysis.

Analytical data for the observed parameters are summarized in the decision tables in Appendix A. The site and sample locations are shown in Figure 3-4.

Risk-based Concentrations and Background Comparisons for Soils. Because no organic constituents were detected above RBCs, only concentrations of naturally occurring metals warranted evaluation. Noncarcinogens exceeding the background concentration and the RBC for ingestion (which is 10 percent of the Region III RBC) included manganese. Manganese was exceeded in the samples collected approximately 6 ft below ground surface (bgs). Deeper samples are not available for direct exposure and do not warrant additional investigation.





MSFC-Key Map

LEGEND

- Soil Sample Analyzed for COPCs
- Soil Sample Analyzed for TCL/TAL
- Fence

FIGURE 3-4
MSFC-047
HYDROSTATIC DUMP LAGOON
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Soil Leaching to Groundwater Comparisons. The only chemical exceeding screening values protective of groundwater was barium (180 mg/kg). Recent data from MSFC's groundwater monitoring program at the IWTF show that the mean concentration detected for barium was 0.0692 mg/L. This value is below the MCL of 1 mg/L. No further investigation of this pathway is warranted.

Residential Risk Assessment. As detailed in Appendix B, the residential risk assessment for the soils resulted in risk of 3×10^{-7} and an HI of 0.07 for a hypothetical adult resident and an HI of 0.95 for a hypothetical child resident.

The site is not located over a regional groundwater contaminant plume. The groundwater was evaluated for human health risks using data generated from the RCRA monitoring program. Only iron and manganese were detected above both the background and a health-based concentration level. The human health risk assessment concluded that the groundwater beneath the OU-9 sites does not present significant risks based on the hazard indexes evaluated for iron and manganese. There were no carcinogenic chemicals detected above background levels in the groundwater.

The residential human health risk assessment concluded that the soil and groundwater at the site do not present human health risks under existing conditions and potential future use scenarios.

Ecological Risks. The potential source of exposure attributable to the hydrostatic dump lagoon is waste that may have saturated soils within the lagoon. Surface soils within the lagoon represent the most significant potential exposure medium to ecological receptors.

Analysis of shallow boring samples indicated the presence of chromium, cyanide, and nickel at levels just above background concentration levels.

The hydrostatic dump lagoon does not have a natural setting that would provide any habitat for ecological receptors. Given the limited nature and extent of the parameter occurrence and the lack of a natural setting in which ecological receptors would occur, exposure to ecological receptors is incomplete. MSFC-047 does not have an ecological receptor exposure potential based on the data evaluated for this site and, therefore, no further evaluation, is warranted.

3.3.4 Description of the "No Further Action" Alternative

MSFC-047, Hydrostatic Dump Lagoon, is a non-operational lagoon located at the former IWTF. No further investigation or remedial action for the soils or groundwater is necessary for the protection of human health or the environment, based on an analysis of available sample results and pertinent information for this site. Therefore, the selected remedial alternative for the soils at the site is NFA. No additional sampling or monitoring of the soils or groundwater will be necessary because the conditions at the site are protective of human health and the environment.

No further groundwater monitoring will be required under RCRA as a result of the NFA alternative.

3.4 MSFC¾048-Mix Tank

3.4.1 Site Characteristics

The concrete mix tank (MSFC-048) is a non-operational tank in the northeastern corner of the hydrostatic dump lagoon (MSFC-047). The tank is 20 ft by 14 ft and 8½ ft deep (280 ft^2). Industrial rinse water was used to clean out the plating waste residue in the pipes after the plating wastes were transferred to the IWTF from Building 4760. This unit received the rinse water, along with waste associated with the spray paint booth located in Building 4760. The rinse water was treated with sodium hydroxide from the caustic storage tank (MSFC-A) to adjust the pH to a range of 7.0 to 7.5. The water was then discharged into the hydrostatic dump lagoon.

No previous sampling of this unit is known to have occurred before the RI. Consideration was given to the possibility that subsurface soil may have been contaminated by leaching organic compounds and metals. The wastewater received by this unit consisted mainly of metals and cyanide; thus, the COPCs for the surrounding soils are metals, cyanide, and hexavalent chromium. Groundwater contamination is not considered probable because the unit is lined with concrete. Current air releases also are not considered probable because the tank is no longer receiving waste.

3.4.2 Current and Potential Future Land and Resource Uses

MSFC-048, Mix Tank, is a non-operational tank located at the former IWTF. Wastes were removed from the tank when the IWTF was taken out of service. The tank was left in place but is no longer in service.

As noted in Section 3.1.2, the Army has granted NASA an irrevocable lease of the MSFC facility through June 30, 2059. The adjacent and surrounding lands are contained within MSFC or RSA, are used for industrial purposes, and will be continue to be used for industrial purposes in the future. The WNWR is to the south of OU-9, however this area of the refuge is designated as restricted access and is not readily accessible by the public.

Indian Creek and some small tributaries are west and south of OU-9. However, these areas have been designated as no fishing zones because of previous contamination from sources other than MSFC. No fishing signs have been posted in these areas. These areas are outside the MSFC property boundary, but within RSA, and access to the offsite public is restricted. In addition, most of the area along the Creek is inaccessible because of overgrowth and is not conducive for recreational use.

Groundwater beneath the site does not pose a residential risk, and is not currently used as a drinking water source. Future use of the groundwater as a drinking water source is not anticipated.

3.4.3 Summary of Site Risks

Five soil borings were installed at the site approximately 5 ft from the concrete structure, as shown in Figure 3-5. A horizontal distance of 5 ft was selected because slug test data in the clay residuum collected at the IWTF (NASA, 1992) led to estimated permeabilities that

would allow wastewater to migrate from the units at a rate of approximately 0.001 foot/day.

The tank was inspected at the time of sampling and appeared to be intact, which indicates that seepage of waste from the unit over time was not expected. However, for the purposes of this assessment it was assumed that waste or water has seeped from the unit. Assuming that waste or water has seeped from the unit with no vertical migration during the 25 years the unit has been in operation the horizontal seepage would extend approximately 9½ ft. The unit was closed 8 years ago, indicating that the horizontal seepage of any waste remaining in the unit when it was taken offline would have migrated approximately 3 ft from the unit (assuming there has been no vertical migration). Assuming no vertical migration is a conservative assumption and provides for the maximum amount of horizontal seepage. If it is assumed that vertical migration has occurred, the concentrations of waste at the outer edge of the migration plume would be even further diluted. Therefore, samples were collected closer to the unit, but within the 3- to 9½- foot area of expected contamination.

Two soil samples were collected from borings SB09-019 through SB09-020 (10 samples): one from a depth of 0 to 12 inches and the second from a depth of approximately 1 foot below the base of the structure or immediately above the groundwater table whichever was encountered first. Eight samples collected from four of the borings were analyzed for the COPCs. The two remaining samples collected from one of the borings (SB09-019) located on the southern side were analyzed for the TCL/TAL. The samples collected from this boring were selected for TCL/TAL analyses because the topography of the IWTF slopes south; therefore, surface spills would migrate south. The investigation area covered approximately 1,100 ft2.

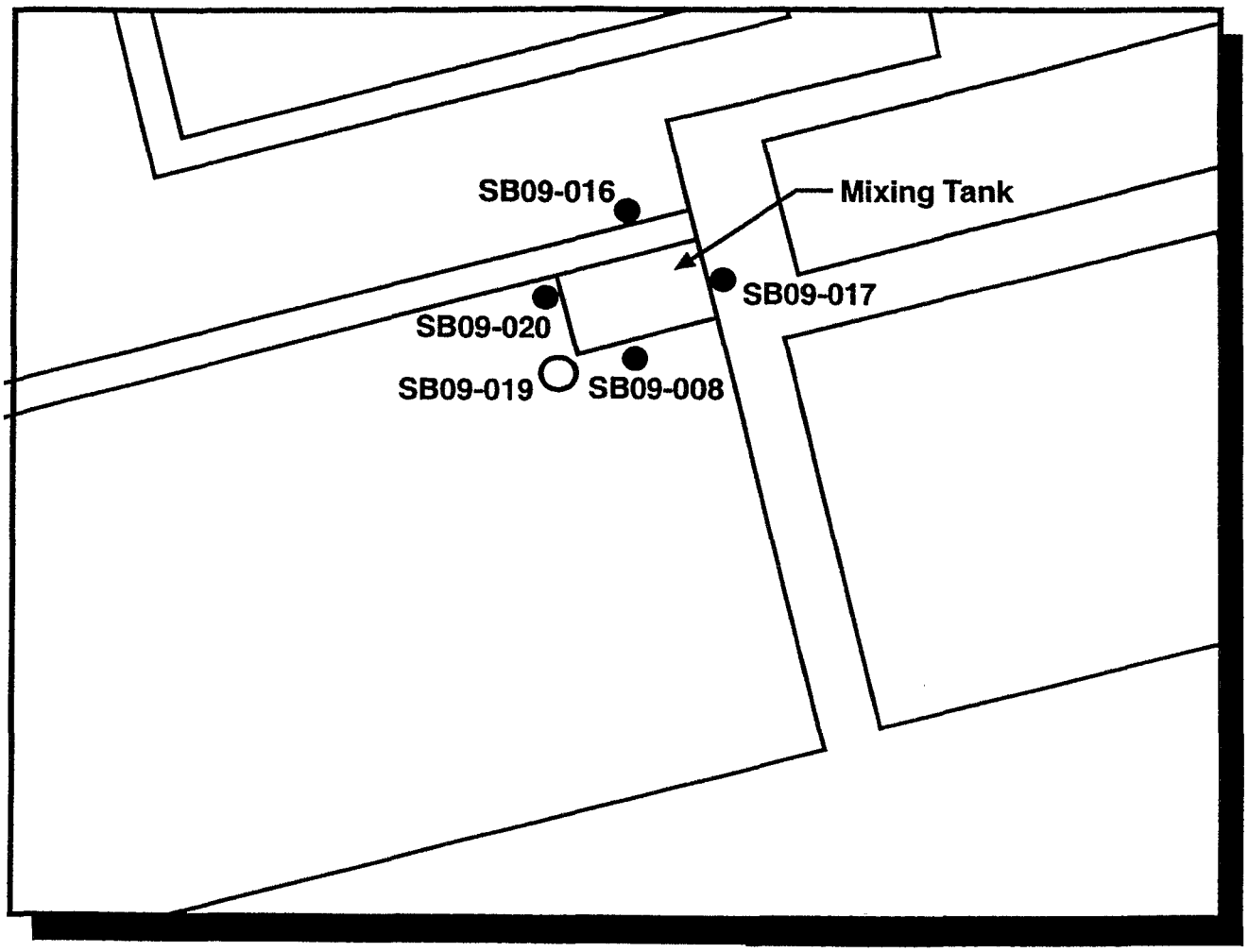
Analytical data for the observed parameters are summarized in the decision tables in Appendix A. The site and sample locations are shown in Figure 3-5.

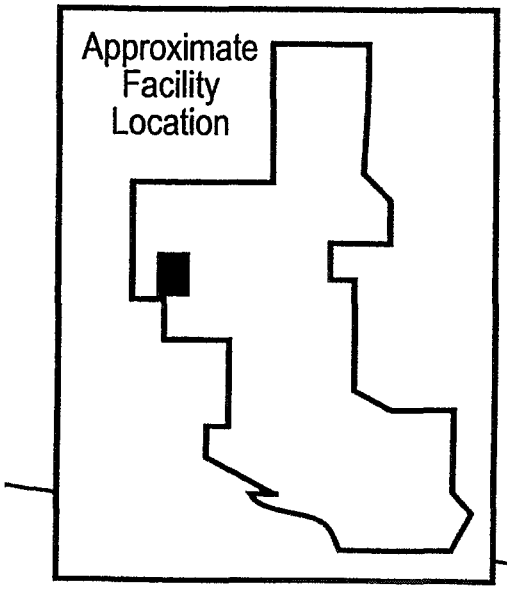
Risk-based Concentrations and Background Comparisons for Soil. Because no organic constituents were detected above RBCs, only concentrations of naturally occurring metals warranted evaluation. Noncarcinogens exceeding the background concentration and the RBC for ingestion (which is 10 percent of the Region III RBC) included manganese. Manganese was exceeded in the samples collected at the surface and in the samples collected approximately 6 ft bgs. The maximum manganese concentration exceeded its background value, but was within the same order of magnitude of this value.

Soil Leaching to Groundwater Comparisons. Chemicals exceeding screening values protective of groundwater included barium and manganese. Recent data from MSFC's groundwater monitoring program at the IWTF show that the mean concentration detected for barium was 0.0692 mg/L and for manganese was 2.2 mg/L. These values are below the MCLs or RBCs for tap water. No further investigation of this pathway is warranted.

Residential Risk Assessment. As detailed in Appendix B, the residential risk assessment for the soils resulted in a risk of 1×10^{-10} and an HI of 0.03 for a hypothetical adult resident and an HI of 0.20 for a hypothetical child resident.

The site is not located over a regional groundwater contaminant plume. The groundwater was evaluated for human health risks using data generated from the RCRA monitoring





MSFC-Key Map

LEGEND

- Soil Sample Analyzed for COPCs
- Soil Sample Analyzed for TCL/TAL

FIGURE 3-5
MSFC-048
MIX TANK
NASA-Marshall Space Flight Center
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program. Only iron and manganese were detected above both the background and a health-based concentration level. The human health risk assessment concluded that the groundwater beneath the OU-9 sites does not present significant risks based on the hazard indexes evaluated for iron and manganese. There were no carcinogenic chemicals detected above background levels in the groundwater.

The residential human health risk assessment concluded that the soil and groundwater at the site do not present human health risks under existing conditions and potential future use scenarios.

Ecological Risks. The potential source of exposure attributable to the mix tank is waste that may have saturated soils adjacent to the tank. Surface soils outside the tank represent the most significant potential exposure medium to ecological receptors. Analyses of shallow boring samples indicated the presence of cyanide, manganese, nickel, and silver at levels just above background concentration levels. It should be noted that manganese is an essential element.

The mix tank does not provide a natural setting that would provide any habitat for ecological receptors. Given the limited nature and extent of the parameter occurrence and the lack of a natural setting in which ecological receptors would occur, exposure to ecological receptors is incomplete. MSFC-048 does not have an ecological receptor exposure potential based on the data evaluated for this site and, therefore, no further evaluation is warranted.

3.4.4 Description of the "No Further Action" Alternative

MSFC-048, Mix Tank, is a non-operational tank located at the former IWTF. No further investigation or remedial action for the soils or groundwater is necessary for the protection of human health or the environment, based on an analysis of available soil sample results and pertinent information for the site. Therefore, the selected remedial alternative for the soils and groundwater at the site is NFA. No additional sampling or monitoring of the soils or groundwater will be necessary because the conditions at the site are protective of human health and the environment.

No further groundwater monitoring will be required under RCRA as a result of the NFA alternative.

3.5 MSFC-049/050¾ East and West Ultimate Lagoons

3.5.1 Site Characteristics

The East Ultimate Lagoon (MSFC-049) was constructed in 1967 and continued in operation until 1975. The lagoon's liner was constructed of concrete that was 4 inches thick and had an impervious, chemical-resistant Hypalon liner bonded to its surface. The rectangular lagoon bottom was 30 ft by 83 ft, and the walls sloped outward toward the top of the basin, which was 123 ft by 70 ft (8,610 ft^2).

The West Ultimate Lagoon (MSFC-050) was in operation between 1972 and 1979. The unit had a PVC liner supported by a soil and sand underliner and a drain system that collected leachate. The unit was covered by a roof to reduce the entrance of rainwater. The rectangu-

lar lagoon bottom was 30 ft by 68 ft, and the walls sloped outward toward the top of the basin, which was 99 ft by 61 ft (approximately 6,040 ft^2).

The units were used for dewatering and long-term storage of metal hydroxide sludge and other waste generated from the wastewater treatment system.

MSFC-049 and MSFC-050 (Figure 3-6) were closed in accordance with RCRA regulations and certified in January 1990. These closures are described in the *Post-Closure Permit Application for the Ultimate Lagoons and IWTB* (1988).

Existing foundations and structures within the sites, as well as the underground piping, were removed before backfilling. All standing water and sludges were removed and drummed for offsite disposal. Demolished material was broken into small pieces and placed in the lagoons as fill material. The remaining excavation was backfilled with a high clay content, low-permeability soil. A clay cap was placed over the backfill to provide a low-permeability barrier to infiltration. The site was protected from erosion by grassing. A layer of topsoil was placed over the cap and seeded with common Bermuda grass seed. Lime, fertilizer, and mulch also were used to promote grass establishment.

3.5.2 Current and Potential Future Land and Resource Uses

MSFC-049 and MSFC-050 have been closed under RCRA. Existing foundations and structures within the site, as well as the underground piping, were removed before backfilling. The site was protected from erosion by grassing. The site has been maintained in a grassy condition and is not used for any other purpose.

As noted in Section 3.1.2, the Army has granted NASA an irrevocable lease of the MSFC facility through June 30, 2059. The adjacent and surrounding lands are contained within MSFC or RSA, are used for industrial purposes, and will continue to be used for industrial purposes in the future. The WNWR is to the south of OU-9, however this area of the refuge is designated as restricted access and is not readily accessible by the public.

Indian Creek and some small tributaries are west and south of OU-9. However, these areas have been designated as no fishing zones because of previous contamination from sources other than MSFC. No fishing signs have been posted in these areas. These areas are outside the MSFC property boundary, but within RSA, and access to the offsite public is restricted. In addition, most of the area along the Creek is inaccessible because of overgrowth and is not conducive for recreational use.

Groundwater beneath the site does not pose a residential risk, and is not currently used as a drinking water source. Future use of the groundwater as a drinking water source is not anticipated.

3.5.3 Summary of Site Risks

In May 1998, one soil sample was collected at approximately 1 foot below the base of the units into the native soil from each of the 10 borings at MSFC-049/050. The investigation covered the combined lagoon area of approximately 30,000 ft^2. The actual base of the closed units was determined for sampling purposes by noting the depth within the boring at which fill soil changed to native material. All of the samples were collected above the water table. One sample (SB09-55) was analyzed for the TCL/TAL parameters. The soil boring was

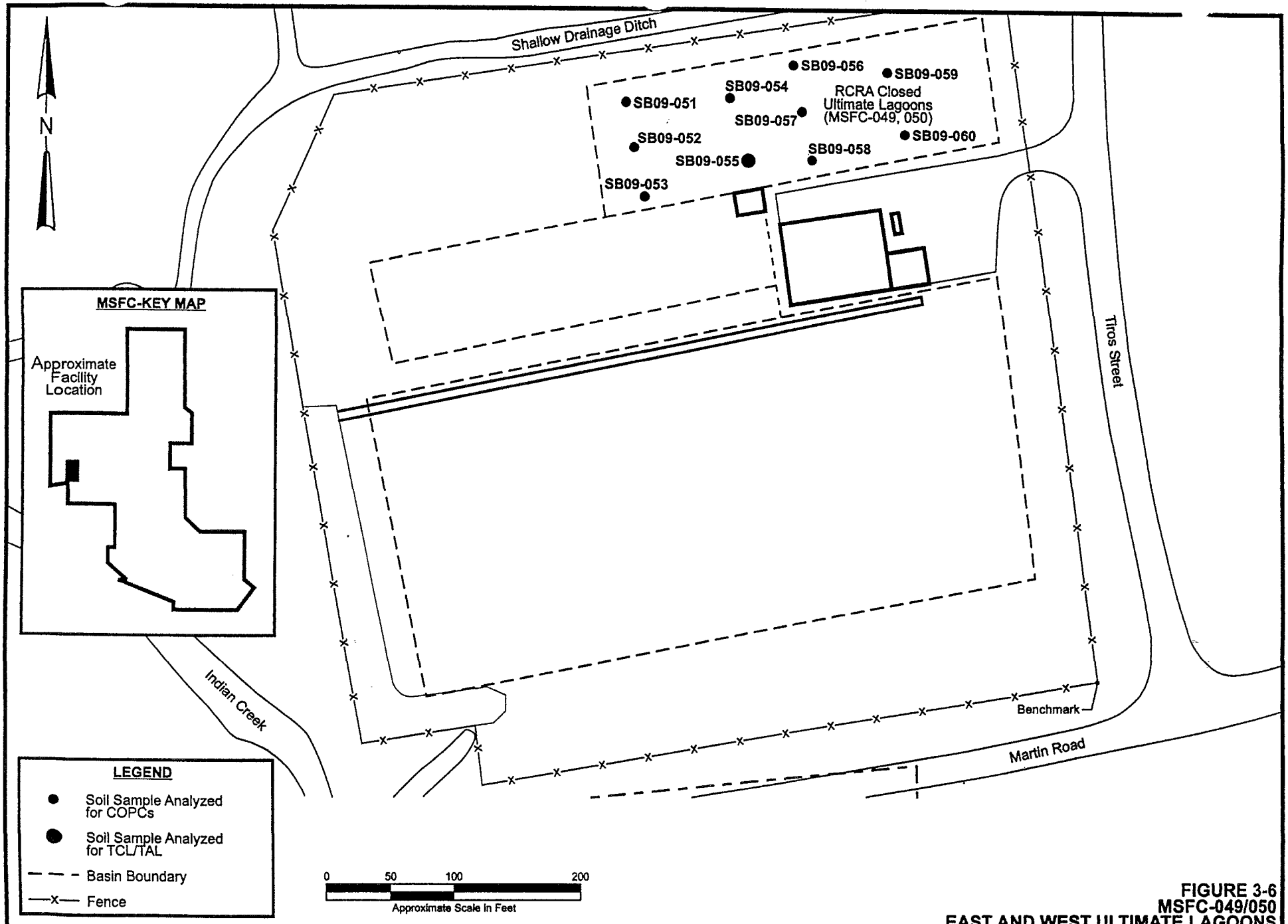


FIGURE 3-6
MSFC-049/050
EAST AND WEST ULTIMATE LAGOONS
NASA - Marshall Space Flight Center
OU-9 Record of Decision

selected for TCL/TAL analysis because the IWTF slopes south; therefore, surface spills probably would migrate downgradient. The nine remaining samples were analyzed for the COPCs. The MSFC-049/050 data are from subsurface soils; there are no COPCs for the surface soil.

Analytical data for the observed parameters are summarized in the decision tables in Appendix A. The site and sample locations are shown in Figure 3-6.

Risk-based Concentrations and Background Comparisons for Soils. Because no organic constituents were detected above RBCs, only concentrations of naturally occurring metals warranted evaluation. Inorganic constituents exceeding the background concentration included arsenic, lead, manganese, and nickel. There was only one exceedance of each of the constituents. In addition, the lead and manganese exceedances were within an order of magnitude of the background concentrations.

Soil Leaching to Groundwater Comparisons. The only chemicals exceeding screening values protective of groundwater were lead, manganese, and nickel. There was only one exceedance of each of the constituents. Recent data from MSFC's groundwater monitoring program at the IWTF show that the mean concentrations detected for barium, lead, manganese, and nickel were 0.0692, 5.03, 2.99, and 0.0419 mg/L, respectively. These values are below the MCL or RBC for tap water. No further investigation of this pathway is warranted.

Residential Risk Assessment. As detailed in Appendix B, the residential risk assessment for the soils resulted in an HI of 0.02 for a hypothetical. adult resident and an HI of 0.02 for a hypothetical child resident. There was no risk assessment performed for surface soils.

The site is not located over a regional groundwater contaminant plume. The groundwater was evaluated for human health risks using data generated from the RCRA monitoring program. Only iron and manganese were detected above both the background and a health-based concentration level. The human health risk assessment concluded that the groundwater beneath the OU-9 sites does not present significant risks based on the hazard indexes evaluated for iron and manganese. There were no carcinogenic chemicals detected above background levels in the groundwater.

The residential human health risk assessment concluded that the soil and groundwater at the site do not present human health risks under existing conditions and potential future use scenarios.

Ecological Risks. No COPCs have been identified because these units were closed under RCRA. In addition, the sites do not have a natural setting that would provide habitat for ecological receptors. Exposure to ecological receptors is incomplete, given the lack of a natural setting in which ecological receptors would occur. MSFC-049 and 050 do not have an ecological receptor exposure potential, based on the data evaluated for the site and, therefore, no further evaluation is warranted.

3.5.4 Description of the "No Further Action" Alternative

MDFC-049 and 050 (East and West Ultimate Lagoons) have been closed under RCRA and are non-operational. No further investigation or remedial action is necessary for the soil or groundwater at these sites for the protection of human health or the environment, based an

analysis of available pertinent information for these sites. Therefore, the selected remedial alternative for the soil and groundwater at these sites is NFA. No additional sampling or monitoring of the soil or groundwater at these sites will be necessary because the conditions at the sites are protective of human health and the environment.

No further post closure inspection or maintenance activities or groundwater monitoring will be required under RCRA as a result of the NFA alternative.

3.6 MSFC-A–Caustic Storage Tank

3.6.1 Site Characteristics

The storage tank (MSFC-A) was a sodium hydroxide (caustic) underground storage tank (UST) used from 1969 to 1984. The unit was equipped with a control valve to regulate the inflow of caustic solution to the concrete receiving tank (MSFC-045). The tank is still in place, although it is non-operational. This galvanized steel UST has a diameter of 4 ft and is approximately 10 to 12 ft deep. The area of investigation was approximately 15 ft by 15 ft (225 ft^2).

No previous sampling of this unit is known to have occurred before the RI. Consideration was given to the possibility that subsurface soil may have been contaminated by leaching organic compounds and metals from surrounding sites. The wastewater received by the surrounding units consisted mainly of metals and cyanide; thus, the COPCs for the surrounding soils are metals, hexavalent chromium, and cyanide. Groundwater contamination is not considered probable because the unit is a galvanized steel UST. Current air releases also are not considered probable because the tank is empty and no longer used.

3.6.2 Current and Potential Future Land Resource Uses

MSFC-A was a sodium hydroxide (caustic) UST that is non-operational. The tank was left in place but is no longer in use.

As noted in Section 3.1.2, the Army has granted NASA an irrevocable lease of the MSFC facility through June 30, 2059. The adjacent and surrounding lands are contained within MSFC or RSA, are used for industrial purposes, and will continue to be used for industrial purposes in the future. The WNWR is to the south of OU-9, however this area of the refuge is designated as restricted access and is not readily accessible by the public.

Indian Creek and some small tributaries are west and south of OU-9. However, these areas have been designated as no fishing zones because of previous contamination from sources other than MSFC. No fishing signs have been posted in these areas. These areas are outside the MSFC property boundary, but within RSA, and access to the offsite public is restricted. In addition, most of the area along the Creek is inaccessible because of overgrowth and is not conducive for recreational use.

Groundwater beneath. the site does not pose a residential risk, and is not currently used as a drinking water source. Future use of the groundwater as a drinking water source is not anticipated.

3.6.3 Summary of Site Risks

In May 1996, five soil borings were installed at the site approximately 5 ft from the tank, as shown in Figure 3-7. A horizontal distance of 5 ft was selected because slug test data in the clay residuum collected at the IWTF (NASA, 1992) led to estimated permeabilities that would allow wastewater to migrate from the units at a rate of approximately 0.001 foot/day.

The unit has been in place for approximately 25 years. Assuming that waste or water has seeped from the unit over this entire time and that there has been no vertical migration, the horizontal seepage would extend approximately 9½ ft. The unit was closed 8 years ago, indicating that the horizontal seepage of any waste remaining in the unit when it was taken offline would have migrated approximately 3 ft from the unit (assuming that there has been no vertical migration). An unknown extent of vertical migration has occurred, thereby diluting the concentrations of the waste at the outer migration portion. Therefore, samples were collected closer to the unit, but within the 3- to 9½ -foot area of expected contamination. The distance of 5 ft was selected as a biased location for the sampling.

Two soil samples were collected from borings SB09-001 through SB09-005 (10 samples): one from a depth of 0 to 12 inches and the second from a depth of approximately 1 foot below the base of the tank or immediately above the groundwater table, whichever was encountered first. Eight samples collected from four of the borings, were analyzed for the COPCs (metals, hexavalent chromium, and cyanide). The two remaining samples collected from one of the borings (SB09-003) located on the southern side were analyzed for the TCL/TAL.

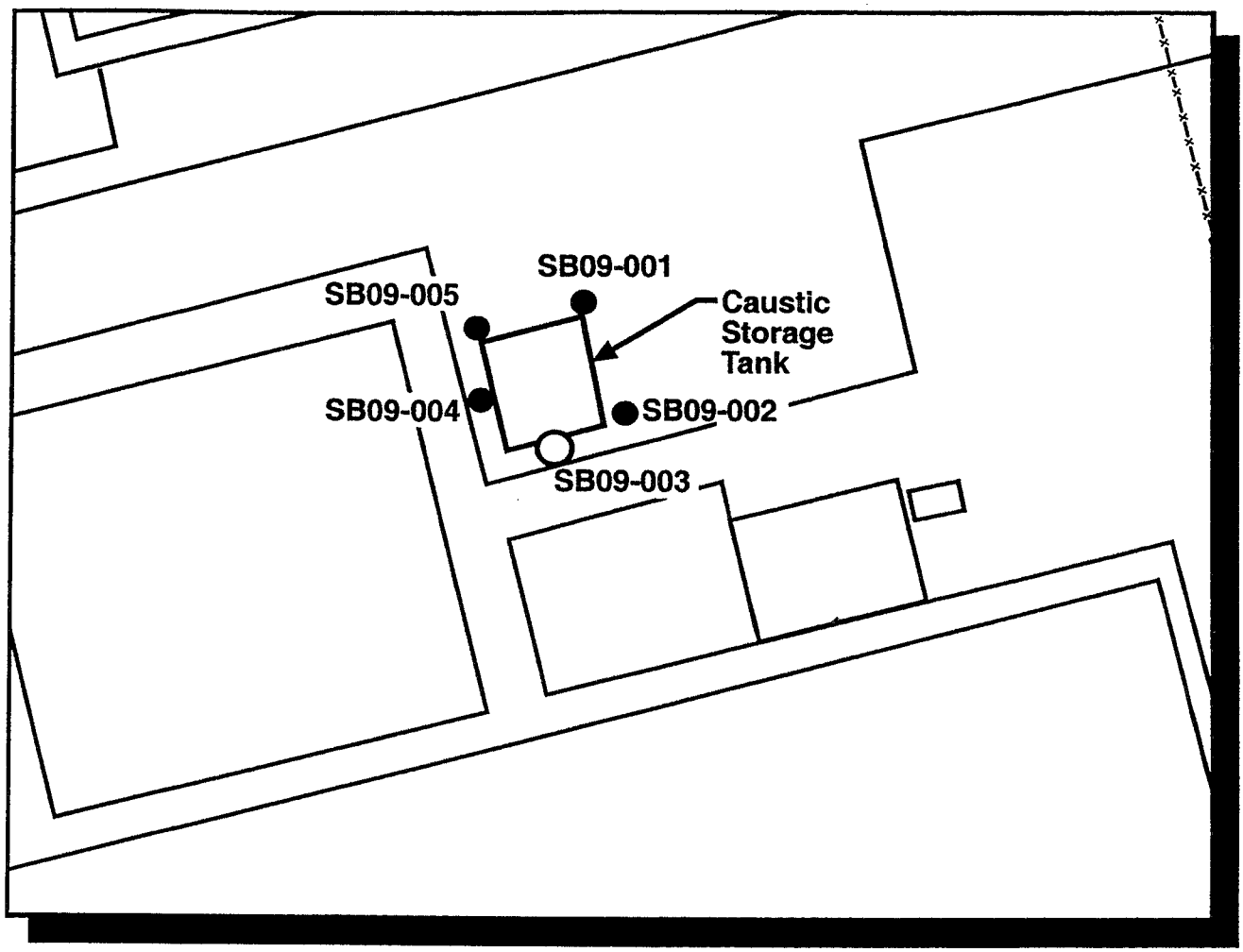
The samples collected from the southern boring were selected for TCL/TAL analyses because the topography of the IWTF slopes south; therefore, surface spills would migrate south.

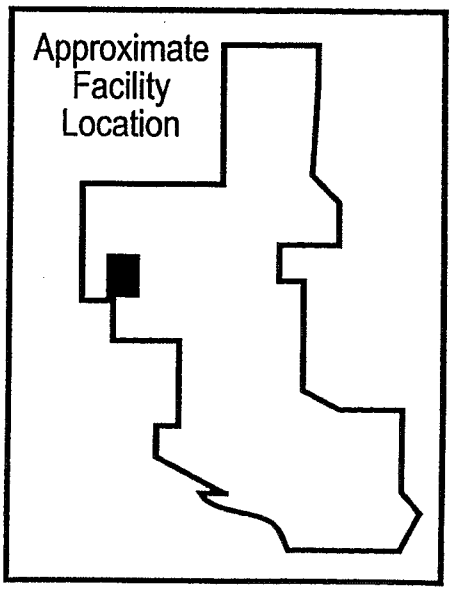
Analytical data for the observed parameters are summarized in the decision tables in Appendix A. The site and sample locations are shown in Figure 3-7.

Risk-based Concentrations and Background Comparisons for Soils. Because no organic constituents were detected above RBCs, only concentrations of naturally occurring metals needed to be evaluated. Noncarcinogens exceeding the background concentration and the RBC for ingestion (which is 10 percent of the Region III RBC included cadmium and manganese. These exceeded these values only in samples collected at approximately 6 ft bgs. The maximum cadmium and manganese concentrations exceeded their background values, but were within the same order of magnitude of their respective values. The maximum concentration of cadmium detected (4.4 mg/kg) is similar to the RBC of 3.9 mg/kg; also, deeper samples are not available for direct exposure and do not warrant additional investigation.

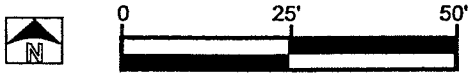
Cadmium did not exceed the RBCs for industrial and residential receptor exposures, as presented in the EPA Region III RBCs, indicating a hazard quotient chemical below 1.

Soil Leaching to Groundwater Comparisons. Chemicals exceeding screening values protective of groundwater included acetone, barium, chromium, manganese, and nickel. As noted in the data quality evaluation, the acetone detections probably are from incomplete





MSFC-Key Map



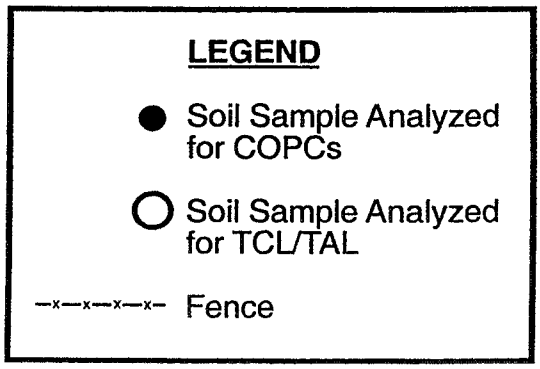


FIGURE 3-7
MSFC-A
CAUSTIC STORAGE TANK
NASA-Marshall Space Flight Center
OU-9 Record of Decision

CH2MHILL

drying of the isopropanol during decontamination procedures during the sampling event. Further evaluation of acetone is not warranted.

Recent data from MSFC's groundwater monitoring program at the IWTF showed that the mean concentrations detected for barium, manganese, and nickel were 0.0692, 2.22, and 0.0419 mg/L, respectively. These values are below the MCLs or RBCs for tap water. Chromium was not detected during the groundwater sampling. Further investigation of this pathway is not warranted.

Residential Risk Assessment. As detailed in Appendix B, the residential risk assessment for the soils resulted in a risk of 7×10^{-8} and an HI of 0.10 for a hypothetical adult resident and an HI of 0.60 for a hypothetical child resident.

The site is not located over a regional groundwater contaminant plume. The groundwater was evaluated for human health risks using data generated from the RCRA monitoring program. Only iron and manganese were detected above both the background and a health-based concentration level. The human health risk assessment concluded that the groundwater beneath the OU-9 sites does not present significant risks based on the hazard indexes evaluated for iron and manganese. There were no carcinogenic chemicals detected above background levels in the groundwater.

The residential human health risk assessment concluded that the soil and groundwater at the site do not present human health risks under existing conditions and potential future use scenarios.

Ecological Risks. The potential source of exposure attributable to the caustic storage tank is waste that may have saturated soils adjacent to the tank. The tank is underground and does not provide an immediate source of exposure. Only wastes that have leaked and saturated the soils to the surface are of potential concern to ecological receptors. An analysis of shallow boring samples indicated the presence of cyanide at a level just above background concentration levels. The caustic storage tank does not provide a natural setting that would provide a habitat for ecological receptors. The tank is placed in a physically disturbed setting characterized as an industrial setting. Exposure to ecological receptors is incomplete, given the lack of a natural setting in which ecological receptors would occur. MSFC-A does not have an ecological receptor exposure potential, based on the data evaluated for the site and, therefore, no further evaluation is warranted.

3.6.4 Description of the "No Further Action Alternative"

MSFC-A, Caustic Storage Tank, is a non-operational tank located at the former IWTF. No further investigation of the soils or remedial action for the soils or groundwater is necessary for the protection of human health or the environment based an analysis of available soil sample results and pertinent information for the site. Therefore, the selected remedial alternative for the soils or groundwater at the site is NFA. No additional sampling or monitoring of the soils or groundwater will be necessary because the conditions at the site are protective of human health and the environment. No further groundwater monitoring will be required under RCRA as a result of the NFA alternative.

3.7 Groundwater Summary

As detailed in Appendix B, a conservative residential risk assessment for the soils and groundwater at OU-9 was performed. Soil data from each site were evaluated separately, and summaries of the risk assessment are included in the data evaluation for each site in this section. The groundwater data were evaluated on an OU-wide basis; the summary of the groundwater risk assessment is presented in this subsection.

The groundwater COPCs selected included iron and manganese. These two inorganic chemicals were the only chemicals detected above background and a health-based concentration level. They are distributed in groundwater across MSFC at similar concentrations as those observed in the wells at the IWTF. The MSFC background wells may not be truly representative of MSFC hydrogeological conditions that may have naturally elevated levels of these background constituents.

The exposure assessment was completed to characterize the potential for exposure to site-related COPCs to a future hypothetical resident. The results of the exposure assessment are represented as chronic daily intakes (CDIs) for carcinogenic or noncarcinogenic endpoints specific to each COPC and receptor identified. The groundwater beneath OU-9 is not currently used, and it is unlikely to be used for potable purpose in the future. Much of the site's shallow groundwater is likely to release to the downgradient stream and wetlands (possibly springs). At ADEM's request, a conservative human health evaluation was performed using a future hypothetical residential receptor exposure scenario for exposures to soils and groundwater.

The toxicity assessment revealed that there were no carcinogenic COPCs in site groundwater.

The risk characterization included the qualitative and quantitative evaluation of potential risks associated with COPCS detected in the groundwater beneath OU-9. The groundwater data indicate that the groundwater is mostly free of organic contamination. Only naturally occurring inorganic chemicals were detected. There were no carcinogenic chemicals detected above background in the groundwater. Thus, only a noncarcinogenic HI was estimated for a hypothetical adult and a child. The total HI from the average observed iron and manganese concentrations was 0.6 for an adult, which is below a value of 1.0; it was 1.4 for a child, which is slightly above a value of 1.0. Though the HI was slightly greater than 1.0, the risks associated with iron and manganese are considered acceptable because iron and manganese are nutritionally essential for human metabolism and the concentrations are not present at high enough levels to pose a risk to human health.

The groundwater beneath OU-9 was free of organic contamination. Concentrations of a few naturally occurring chemicals were detected above background concentrations in the groundwater beneath OU-9. There is no direct exposure to the ecological receptors at the unit. Most of the groundwater monitoring wells are shallow (residuum) wells. The residuum groundwater data are indicative of the groundwater that may discharge to surface water (springs and/or streams such as Indian Creek) in the vicinity of OU-9. Therefore, the groundwater-detected concentrations were compared directly to the federal ambient water quality criteria (AWQC) (Tier II) for surface water. This comparison is conservative because groundwater discharging to the surface will mix with groundwater from the regional

aquifer and surface water. The concentration at the surface will be lower than in the groundwater as a result of this dilution. On the basis of this conservative screening comparison, only manganese was detected frequently above the AWQC concentration for comparison. The freshwater aquatic criterion published by Region III EPA is 14.5 mg/L, and the mean manganese concentration is below this value. The other inorganic chemicals either were similar to background levels or were infrequently detected (Table 3-2). Thus, release of the site groundwater to the surface water bodies or deeper groundwater from beneath the unit is not considered to present an ecological concern.

TABLE 3-2
Surface Water Ecological Criteria Comparison With Groundwater
OU-9 Record of Decision

Parameter Name	Number of Analyses	Number of Detects	Mean of Detects	Units	Background	AWQC
Barium	78	74	6.92E-02	mg/L	4.13E-02	N/A
Copper	78	1	1.60E-02	mg/L	N/A	6.54E-03
Iron	78	77	2.27E+00	mg/L	4.64E+00	1.00E+00
Lead	78	1	5.03E+00	mg/L	2.80E-03	1.32E-03
Magnesium	78	77	8.33E+00	mg/L	7.22E+00	N/A
Manganese	78	57	2.22E+00	mg/L	2.16E-01	N/A
Nickel	78	24	4.19E-02	mg/L	3.54E-02	8.77E-02
Potassium	78	77	1.06E+00	mg/L	2.62E+00	N/A
Sodium	78	77	8.98E+00	mg/L	8.04E+00	N/A
Zinc	78	13	2.29E+00	mg/L	9.21E-02	5.89E-02

Notes:
N/A = no value available

SECTION 4

Responsiveness Summary

This section of the ROD is reserved to address comments from the general public regarding the *Proposed Plan for MSFC OU-9 Sites* (NASA, May 1999).

An opportunity for public discussion and comment was provided during a public information meeting on September 13, 1999. A 30-day formal public comment period also was provided from September 6, 1999, to October 5, 1999. No public comments were received.

SECTION 5

References

Listed below are references to the CERCLA documents in the repositories:

A. T. Kearney, Inc. July 1989. *Interim RCRA Facility Assessment of the Marshall Space Flight Center*.

CH2M HILL. May 1994. *Biological Assessment Alabama Cave Shrimp* (Palaemonaias alabamae).

Environmental Protection Systems, Inc. October 1990. *Phase I Baseline Environmental Assessment for Marshall Space Flight Center. Lockheed Missile and Space Co.*

ERC Environmental Energy Services Company, Inc. October 1991. *MSFC Addendum to Groundwater Quality Assessment Report for 4740 WPCF*.

ERC Environmental Energy Systems, Inc. June 1991. *Ground Water Quality Assessment and Report for 4740 WPCF-Volume 1*.

Geraghty & Miller, Inc. February 1991. *Identification and Evaluation of Potential Solid Waste Management Units and Areas of Concern.*

Harmon Engineering Associates, Inc. February 1989. *Preliminary Assessment of CERCLA Candidate Sites and Related Sites of Possible Environmental Significance*.

Harmon Engineering Associates, Inc. June 1988. *Sampling and Analysis Plan: Preliminary Assessment of CERCLA Candidate Sites.*

Harmon Engineering Associates, Inc. April 1988. *Preliminary Assessment and Site Inspection, Hazardous Waste Disposal and Potential Migration from Abandoned Sites*.

MSI-MSFC. *MSFC Centerwide Chemical Inventory, How and Why We Must Do It!!!*

NASA-Redstone Arsenal. August 1991. *Spill Prevention Control and Countermeasure (SPCC) Plan and ISCP for Oil and Hazardous Materials.*

National Aeronautics and Space Administration. August 1999. *MSFC OU-9 Remedial Investigation Report Final.*

National Aeronautics and Space Administration. May 1999. *Proposed Plan for MSFC Surface Media OU-9 Sites.*

National Aeronautics and Space Administration. April 1999. *Proposed Plan for Surface Media Operable Units 1, 5, 6, 7, and 8.*

National Aeronautics and Space Administration. March 1999. *Final MSFC Surface Media Remedial Investigation (RI) Report for Operable Units 1, 5, 6, 7, 8.*

National Aeronautics and Space Administration. March 1999. *Final Surface Media Interim Actions Within MSFC OU-5 at MSFC-088 and 089 Focused Feasibility Study*.

National Aeronautics and Space Administration. December 1998. *Proposed Plan for Interim Action at MSFC-009 and 063.*

National Aeronautics and Space Administration. October 1998. *Draft Final MSFC Ecological Risk Assessment Report.*

National Aeronautics and Space Administration. October 1998. *Surface Media Interim Actions Within MSFC OU-1 at Sites MSFC-009 and 063, Focused Feasibility Study*.

National Aeronautics and Space Administration. September 1998. *Proposed Plan for MSFC OU-10 Sites Proposed for No Further Action.*

National Aeronautics and Space Administration. June 1998. *Final Expanded Site Inspection Report of MSFC OU-10.*

National Aeronautics and Space Administration. December 1997. *Report of MSFC Background Sampling.*

National Aeronautics and Space Administration. March 1997. *NASA MSFC 1996 Groundwater Monitoring Report OU-9: Former Industrial Waste Treatment Facility.*

National Aeronautics and Space Administration. February 1997. *Groundwater Dye Tracing Work Plan.*

National Aeronautics and Space Administration. October 1996. *Remedial Investigation/Feasibility Study Final Work Plan.*

National Aeronautics and Space Administration. July 1996. *Coordination of NRDA Requirements with the Ecological Risk Assessment Processes at MSFC.*

National Aeronautics and Space Administration. June 1996. *Action Memorandum West Test Stand Area Deluge Pond Final.*

National Aeronautics and Space Administration. July 1996. *Preassessment Screen and Preliminary Assessment Plan for the Natural Resource Damage Assessment of MSFC.*

National Aeronautics and Space Administration. March 1996. *Engineering Evaluation/Cost Analysis for a Non-Time-Critical Removal Action at the West Test Stand Area Deluge Pond.*

National Aeronautics and Space Administration. March 1996. *Proposed Plan for a Groundwater Treatment System; West Test Stand Area. April 1996.*

National Aeronautics and Space Administration. April 1996. *Industrial Wastewater Treatment Facility Site Description and Activities Report.*

National Aeronautics and Space Administration. April 1996. *OU-9 Soils Investigation Work Plan (Final).*

National Aeronautics and Space Administration. March 1996. *NASA MSFC 1995 Groundwater Monitoring Report OU-9: Former Industrial Waste Treatment Facility.*

National Aeronautics and Space Administration. December 1995. *Community Relations Plan.*

National Aeronautics and Space Administration. December 1995. *Focused Feasibility Study for a Groundwater Treatment System–West Test Stand Area.*

National Aeronautics and Space Administration. December 1995. *Pollution Prevention Plan.*

National Aeronautics and Space Administration. May 1994. *Interim Status Groundwater Sampling Plan for the Closed Industrial Waste Treatment Facility.*

National Aeronautics and Space Administration. March 1995. *Confirmatory Sampling Report*.

National Aeronautics and Space Administration. February 1994. *NASA MSFC IWTF Quarterly Groundwater Sampling.*

National Aeronautics and Space Administration. January 1993. *RCRA Facility Investigation (RFI) Work Plan.*

National Aeronautics and Space Administration. October 1992. *MSFC Proposed Alternative Concentration Limits for the Closed Industrial Waste Treatment Facility.*

National Aeronautics and Space Administration. May 1992. *Interim Status: Groundwater Sampling Plan for the Closed Industrial Waste Treatment Facility.*

National Aeronautics and Space Administration. April 1992. *Groundwater Quality Assessment Report*.

National Aeronautics and Space Administration. January 1991. *MSFC Environmental Resources Document*. (Updated June 1996).

National Aeronautics and Space Administration. October 1988. *Site Management Plan*.

U.S. Environmental Protection Agency. September 1997. *Superfund Technical Assistance Grants Quick Reference Fact Sheet.*

U.S. Environmental Protection Agency. 1990. *Introduction to the Resource Conservation and Recovery Act (RCRA).*

Response to Agency Comments on the Draft OU-9 Record of Decision

EPA Comments

Comment 1: *On the figures located throughout the document, the legends identify the soil samples analyzed for Total Compound List/Total Analyte List (TCL/TAL) with a large gray circle. The legends also contain a smaller black circle that represent other soil sampling locations whose analytes are not identified. According to the text, the other samples are analyzed for the contaminants of potential concern (COPCs) identified at the site. However, this information is not provided on any of the figures. For clarity, the figures should include additional information that distinguishes the two types of sample locations from one another. For example, the figures also should state that the smaller black circles indicate sample locations in which samples were analyzed for only COPCs at the site.*

Response: The legend on each figure will be modified to indicate that the small black circles are 'Soil Samples Analyzed for COPCs'.

Comment 2: *Indian Creek and some smaller tributaries located west and south of OU-9 are discussed in the text. It is stated that these areas have been designated as no fishing zones due to previous contamination sources. However, it is not clear whether access to these areas is restricted and/or signs are posted to advise against fishing in these areas. This information should be included in the text.*

Response: In the Current and Potential Future Land and Resources Uses, the paragraph regarding Indian Creek will be revised as follows:

Indian Creek and some small tributaries are located west and south of OU-9. However, these areas have been designated as no fishing zones because of previous contamination from sources other than MSFC. No fishing signs have been posted in these areas. These areas are located outside the MSFC property boundary, but within RSA, and access to the offsite public is restricted. In addition, most of the area along the creek is inaccessible because of overgrowth and is not conducive for recreational use.

ADEM Comments

Comment (page 3-1): *NFA for CERCLA does not mean NFA for RCRA. You still have to go through the clean closure of RCRA to have NFA. Even though we are working oil the sites under CERCLA, they still are being tracked by RCRA. This means that any requirements under RCRA still apply, including, monitoring requirements if applicable. The sites can receive NFA for CERCLA without clean closure for RCRA. For example, if the ROD were for land use controls, the sites would still be under RCRA for non-clean closure. Another example would be if a contamination limit were higher for CERCLA than for RCRA. In this situation you could get NFA for CERCLA if the detection was above the limit, whereas RCRA would still see a risk. What we are really looking for is*

that the new data is such that we can get clean closure under RCRA, and really nothing more. When you submit the data, I will review it for CERCLA, and also take it to RCRA people for their help reviewing it for RCRA requirements. In the event that the new data comes up "clean," then the RCRA work will be paper work here only. If not, then the site remains under RCRA, even if we get NFA for CERCLA. A more accurate statement of the situation would be: "The risk assessment was such to support NFA for CERCLA, with protective limits that support clean closure under RCRA."

THIS IS THE REAL CRITICAL PART: unless I can find where the data has been reviewed by RCRA and accepted, I will have to do this now and let you know what comes of it. It will not affect the CERCLA process, but if for some reason it is unacceptable to RCRA, the sites will not be totally closed out. Unfortunately, due partly to the transition of managers on this project, I do not have all of the history on this OU, so please bear with me.

Response: The text will be revised to add a sentence: The risk assessment was conducted to support NFA for CERCLA, with protective limits that support clean closure under RCRA.

Due to the changes in ADEM project managers, a summary of the decision making history for this OU is provided below.

Three sites within OU-9 (MSFC-044, 049, and 050) were closed under RCRA and certified in January 1990. This closure is described in the *Post-Closure Permit Application for the Ultimate Lagoons and IWTB* (1988). Post-closure inspection and maintenance activities were required under the RCRA closure.

NASA submitted a Part B RCRA permit application for post-closure operations at the former IWTF on August 1, 1991, to EPA and ADEM. This permit included the entire IWTF and proposed long term groundwater monitoring for the IWTF. NASA was awaiting permit application approval and subsequent issuance of the permit when NASA was notified of its incorporation onto the National Priorities List (NPL) under the CERCLA program.

Once NASA was incorporated under the CERCLA program, the ADEM RCRA program agreed to defer all decisions related to the IWTF to the ADEM CERCLA program. At this time the IWTF sites (including those that were clean-closed un der RCRA) were assigned to OU-9 under the CERCLA program.

Soil samples were collected at the remaining five OU-9 sites (MSFC-045, 046, 047, 048, and A) in May 1996 as part of the CERCLA RI process. Subsequently, ADEM agreed that if additional sampling results demonstrated no risk to human health or the environment at the three RCRA closed sites (MSFC-044, 049, and 050) these sites could be approved for NFA under CERCLA. ADEM also agreed that the sites approved for NFA under CERCLA would not require further action under RCRA. David Thompson/ADEM was responsible for obtaining approval from the RCRA program regarding this approach. It is our understanding that ADEM's RCRA program has already approved this approach and that no further data evaluation should be required. Once the sites are approved for NFA under CERCLA, no further actions should be required through the RCRA program.

If further data analysis under the RCRA program is required, the data is available in the *MSFC OU-9 Remedial Investigation Report* (NASA, August 1999).

During the initial sampling efforts in 1995 at OU-9, the closed units were not included, and were assumed to be "clean" based on the RCRA closure. After the RI report for the non-RCRA closed sites was submitted, MSFC and the Agencies discussed what would be needed for the CERCLA closure of all the OU-9 sites, including discontinuing the RCRA ground-water monitoring. The Agencies (lead by ADEM) decided that confirmation subsurface sampling at the closed sites coupled with a residential risk assessment of all the media (including groundwater) would be needed. This is what is included in the approved OU-9 RI report. MSFC requests ADEM to follow through with the previous agreements and obtain whatever RCRA approvals are needed to close these sites under both programs and submit a letter to MSFC indicating that the RCRA groundwater monitoring can be discontinued.

Comment (page 3-6) Residential Risk Assessment: *Assumptions.... are unrealistic. This appears to be awkward. If they are unrealistic, why are you using them? Estimated risks are not considered <u>important</u>. Maybe you should state that it does not pose any risk beyond naturally occurring risk due to arsenic.*

Response: The paragraph will be revised as follows:

"The MSFC-044 data are from subsurface soils; there are no COPCs for the surface soil. Assumptions used for the subsurface soil exposure scenario are highly conservative, because if subsurface soils are excavated and become exposed, they are likely to have lower concentrations due to mixing. In addition, the subsurface soil does not pose risks beyond those due to naturally occurring arsenic levels. Arsenic is detected at a maximum concentration of 19.2 milligrams per kilogram (mg/kg) which is similar to the background level of 13.6 mg/kg. The exposure point concentration for human exposure to arsenic at this site (UCL 95 percent) is 12.9 mg/kg, which is below the background level. Thus, the MSFC-044 potential risks are below the background levels."

Comment (page 3-7): *Refer to NFA comment as it appears to RCRA clean closure. The statements under No Further Action Alternative are not true.*

Response: See response to initial comment (page 3-1). It is our understanding that the RCRA program has approved this approach and no further activities will be required under RCRA as a result of the NFA alternative. In addition, it is expected that discontinuation of the current RCRA groundwater will be approved. No change to the text is recommended.

Comment (page 3-11,12) Ecological Risk: *I have a problem with "Aluminum and iron are common elements, while copper and manganese are essential elements" along with the next sentence. Is it not true that common elements and essential elements can be hazardous if present in sufficient quantities?*

Response: The following sentence will be added: "In addition, these constituents were not present at sufficient quantities to cause adverse effects on exposed receptors."

Comment (page 3-16) Summary of Site Risks: *"5 ft from the concrete structure" is used twice in two adjoining sentences. Also, 1,100 ft^2 does not seem relevant to the paragraph.*

Response: The second sentence will be deleted. The statement about the size of the investigation area will be moved to the end of the third paragraph in this section.

Comment (page 3-16): *In general for the Mix Tank: What about the possibility of vertical migration. Also, the 5-ft distance is fine if you consider the migration is only coming from the edge of the tank. What about a crack in the middle of the tank? You could have horizontal migration that is nowhere near the edge of the tank, but still in very high concentrations.*

Response: As noted in the *Operable Unit-9 Soils Investigation Work Plan* (MSFC, April 1996), the rational for the sampling included only sampling outside the unit, because it was a concrete unit. The migration of a possible leak was calculated based on slug test data, and the direction was estimated based on the topography. Samples were collected from each side of the unit to evaluate a leak from any location, with the TAL/TCL being collected on the side where a leak would have most likely migrated (regardless of where the leak originated). Vertical migration was taken into account in selecting a distance of 5 ft for placement of the sample locations. In addition, the tank was inspected, was holding storm water, and was intact. The paragraph will be revised as follows:

"The tank was inspected at the time of sampling and appeared to be intact which indicates that seepage of waste from the unit over time was not expected. However, for the purposes of this assessment it was assumed that waste or water has seeped from the unit. Assuming that waste or water has seeped from the unit over the 25 years the unit has been in operation with no vertical migration, the horizontal seepage would extend approximately 9 ½ feet. The unit was closed 8 years ago, indicating that the horizontal seepage of any waste remaining in the unit when it was taken offline would have migrated approximately 3 ft from the unit (assuming there has been no vertical migration). Assuming no vertical migration is a conservative assumption and provides for the maximum amount of horizontal seepage. If it is assumed that vertical migration has occurred, the concentrations of waste at the outer edge of the migration plume would be even further diluted. Therefore, samples were collected closer to the unit, but within the 3- to 9½-foot area of expected contamination."

Comment (page 3-22) Ecological Risk: *"No COPCs have been identified because these units were closed under RCRA." If this were possible, it would appear that this site was closed "clean" under RCRA, and therefore should never have been a CERCLA area of concern.*

Response: See response to initial comment (page 3-1). When NASA was incorporated into CERCLA the entire IWTF was placed in OU-9 under CERCLA. NASA was required by CERCLA to continue to include the closed units within this OU even though the sites had been clean-closed under RCRA. Initially, the units were not included in the OU-9 sampling plan and were assumed to be CERCLA clean due to the RCRA closure. After the RI report for the non-RCRA closed sites was submitted, MSFC and the Agencies discussed what would be needed for the CERCLA closure of all the OU-9 sites, including discontinuing the RCRA groundwater monitoring. The Agencies (lead by ADEM) decided that confirmation subsurface sampling at the closed sites coupled with a residential risk assessment of all the media (including groundwater) would be needed. This is why these units have been included in the sampling effort and current OU-9 RI report. No change to the text is recommended.

Comment (page 3-26): *Very last sentence: "Both iron and manganese are nutritionally essential for human metabolism." Please remove this sentence, because both are toxic at appropriately elevated concentrations.*

Response: The intent of this sentence was to justify that even though the HI was 1.4 for a child which was slightly above the acceptable level of 1.0, the risks are minimal since these constituents are nutritionally essential for human metabolism. The sentence will be revised as follows:

"Even though the HI was slightly above 1.0, the risks associated with manganese and iron are considered acceptable since iron and manganese are nutritionally essential for human metabolism and the concentrations are not present at high enough levels to pose a risk to human health."

Comment (page 3-27): *Please clarify the comparison to AWQC. It appears that you are assuming a dilution at a theoretic point, then running your risk assessment.*

Response: This comparison was the result of an agreement with the Agencies. As part of the risk assessment, the possible discharge to surface waters has to be considered. The Agencies (lead by EPA, in this case) stated that a qualitative discussion comparing the groundwater concentrations to the AWQC would suffice as a conservative assessment of the exposure to receptors in surface waters (because dilution and mixing had not been included).

The intent of the paragraph is that the groundwater concentrations were compared directly to the surface water quality criteria and that this comparison is conservative since the actual concentrations discharged to surface water will be lower due to dilution/mixing. The four sentences related to this issue will be revised as follows:

"Therefore, the groundwater detected concentrations were compared directly to the federal ambient, water quality criteria (AWQC) (Tier II) for surface water. This comparison is conservative because groundwater discharging to the surface will mix with the groundwater from the regional aquifer and surface water in the process of the surface discharge. The concentration at the surface will be lower than in the groundwater due to this dilution."

Comment (page B-2): *Please be careful about risking away COPCs due to "naturally occurring" or "essential elements." They should go away for better reasons, such as actual levels or risk assessment values.*

Response: This approach was taken because there are no toxicity factors, MCLs, SMCLs, or health-advisory values for these constituents. These criteria are necessary for conducting risk assessment and HI calculations. This approach was approved by the regulatory agencies during the RI phase of this investigation. No change to the text is recommended.

Comment (page B-3): *Background wells should be characteristic background. If you have a problem with your background wells, you should either get better wells or rely on allowable concentrations.*

Response: The intent of this statement is that iron and manganese are prevalent in wells across the site but not in the background wells. The background sampling approach and data was accepted by the agencies in the *Report of MSFC Background Sampling* (NASA, December 1997). This same issue was also addressed in the approved *Surface Media RI Report* (NASA, March 1999). To avoid any confusion about the background wells, the sentence will be deleted.

Comment (page B-8): *It might be advisable to remove the clarification of 10^{-4} as being 1 in 10,000 as being acceptable risk. Although the EP A accepts this, the public may see the number 10,000 as too small. This is only a concern over public perception of legitimate justification.*

Response: The clarification of 'one chance in 10,000 to one chance in 1,000,000' will be deleted.

Comment (page B-12): *Use of EPC below background is confusing, especially when you add in the maximum detect. Better wording might be more like: "Arsenic had a high hit of 19.2 in one sample, however EPC (average) was 12.9, and is below the 13.6 level in background. Therefore, EPC levels used to characterize risk are at an acceptable level." This argument is strange, however, because EPC is below background, when you previously had concern that background was not characteristic of the site. It looks like you want to pick and choose when to use background to your advantage.*

Response: The same changes will be made as noted in the response to comment on page 3-6 Residential Risk Assessment.

Comment (page B-13) Conclusions: *Is the fourth bullet accurate. Are there no carcinogens, or just none at elevated levels?*

Response: The first sentence of the bullet will be revised as follows: "No carcinogenic chemicals were detected above the screening criteria and therefore, no carcinogenic chemicals were identified as COPCs in the groundwater."

Comment (page B-13) Conclusions: *What does the first bullet mean? Does it mean that residents are physically able to touch the dirt, i.e. there is no fence up, or does it mean that there is low risk if they do touch the dirt?*

Response: The bullet will be revised as follows: The residential risk assessment calculations assumed that the existing fence would be removed and that both surface and subsurface soil are accessible for direct exposure to future residents which is a highly conservative assumption.

Comment (page B-13): *After the conclusions, there are pages of "stuff." There should be some delineation and identification of these pages.*

Response: Divider pages will be added between the risk assessment calculation tables for each site.

OU-9 Groundwater Residential Risk Assessment Calculations

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{C_{gw} * IR\_adj * EF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{C_{gw} * IR * EF * ED}{BW * AT}$$

		Carcinogenic		Noncarcinogenic	
C_{gw} =	Concentration in groundwater (mg/L)	RME		RME	
IR =	Ingestion Rate (L/day)	NA		2	a
IR_{adj} =	Age Specific Ingestion Rate (L - year)/(kg - day)	1.1	b	NA	
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (year)	NA		30	a
BW =	Body Weight (kg)	NA		70	c
AT =	Averaging Time (days)	25550	c	10950	a

Dermal:

Intake for non-carcinogenic and carcinogenic compounds:

$$CDI_{adj} = \frac{C_{gw} * SA\_adj * PC * ET * EF * CF}{AT}$$

$$CDI = \frac{C_{gw} * SA * PC * ET * EF * ED * CF}{BW * AT}$$

C_{gw} =	Concentration in groundwater (mg/L)	RME		RME	
SA=	Surface Area (cm^2)	NA		18150	c,d
SA_{adj} =	Age-Specific Surface area (cm^2-year/kg-day)	10638	e	NA	
PC =	Dermal Permeability Constant (cm/hr)	(Chemical Specific)	f	(Chemical Specific)	f
ET =	Exposure Time (hr/day)	0.25	a	0.25	a
EF =	Exposure Frequency (day/year)	350	a	350	a
ED=	Exposure Duration (year)	NA		30	a
CF =	Conversion Factor (L/cm^3)	1.00E-03		1.00E-03	
BW =	Body Weight (kg)	NA		70	c
AT =	Averaging Time (days)	25550	c	10950	a

Inhalation:

CDI = Ingestion CDI from above[g]

References:

a = Default factors from Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A), Interim Final, December 1989.

b = Age-adjusted groundwater ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{1 \times 6}{15} + \frac{2 \times (30-6)}{70}$$

$$= 1.10 \text{ (L-year)/(kg-day)}$$

c = Default factors adapted from EPA Exposure Factors Handbook, August 1997.

d = Surface area represents whole body (average of male & female adults).

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{6880 \times 6}{15} + \frac{23000 \times (30-6)}{70}$$

$$= 10638 \text{ } (cm^3\text{-year})$$

f = Dermal Permeability Constant for water (0.001) used for constituents without a PC value; all values adapted from EPA, Dermal Exposure Assessment: Principles and Applications, January 1992.

g = follows EPA Region IV guidance (i.e., inhalation of groundwater volatiles while showering/bathing is accounted for by doubling the ingestion volume)

Ingestion:

Intake for non-carcinogenic and carcinogenic compounds:

$$\textbf{CDI} = \frac{C_{gw} * IR * EF * ED}{BW * AT}$$

		Carcinogenic		Noncarcinogenic	
C_{gw} =	Concentration in groundwater (mg/L)	RME		RME	
IR =	Ingestion Rate (L/day)	1	a	1	a
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (year)	6	a	6	a
BW =	Body Weight (kg)	15	a	15	c
AT =	Averaging Time (days)	25550	c	2190	a

Dermal:

Intake for non-carcinogenic and carcinogenic compounds:

$$\textbf{CDI} = \frac{C_{gw} * SA * PC * ET * EF * ED * CF}{BW * AT}$$

C_{gw} =	Concentration in groundwater (mg/L)	RME		RME	
SA=	Surface Area (cm^2)	6880	b, c	6880	b, c
PC =	Dermal Permeability Constant (cm/hr)	(Chemical Specific)	d	(Chemical Specific)	d
ET =	Exposure Time (hr/day)	0.25	a	0.25	a
EF =	Exposure Frequency (day/year)	350	a	350	a
ED=	Exposure Duration (year)	6	a	6	a
CF =	Conversion Factor (L/cm^3)	1.00E-03		1.00E-03	
BW =	Body Weight (kg)	15	a	15	a
AT =	Averaging Time (days)	25550	b	2190	a

Inhalation:

CDI = Ingestion CDI from above[e]

References:

a =Default factors from Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A), Interim Final, December 1989.

b = Default factors adapted from EPA Exposure Factors Handbook, August 1997.

c = Surface area represents whole body (average of male & female children (1 -6 years old)).

d = Dermal Permeability Constant for water (0.001) used for constituents without a PC value; all values adapted from EPA, Dermal Exposure Assessment: Principles and Applications, January 1992.

e = follows EPA Region IV guidance (i.e., inhalation of groundwater volatiles while showering/bathing is accounted for by doubling the ingestion volume)

Appendix A
Groundwater, Fourth Quarter 1997
OU-9 Record of Decision

Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-021R	97Q4	TOTAL IRON	18969.60	UG/L	4640.00	X	11000.00	X	Y
MSFC-021R	97Q4	TOTAL MAGNESIUM	8409.00	UG/L	7220.00	X	50.00	X	Y
MSFC-026	97Q4	TOTAL MAGNESIUM	7813.60	UG/L	7220.00	X	50.00	X	Y
MSFC-029D	97Q4	TOTAL MAGNESIUM	22051.10	UG/L	7220.00	X	50.00	X	Y
MSFC-033D	97Q4	TOTAL MAGNESIUM	23546.80	UG/L	7220.00	X	50.00	X	Y
MSFC-034D	97Q4	TOTAL MAGNESIUM	20579.90	UG/L	7220.00	X	50.00	X	Y
MSFC-039	97Q4	TOTAL MAGNESIUM	11089.30	UG/L	7220.00	X	50.00	X	Y
MSFC-047	97Q4	TOTAL MAGNESIUM	7426.70	UG/L	7220.00	X	50.00	X	Y
MSFC-049	97Q4	TOTAL MAGNESIUM	8739.30	UG/L	7220.00	X	50.00	X	Y
MSFC-051D	97Q4	TOTAL MAGNESIUM	20136.40	UG/L	7220.00	X	50.00	X	Y
MSFC-021R	97Q4	TOTAL MAGNESIUM	4057.30	UG/L	216.00	X	83.95	X	Y
MSFC-032	97Q4	TOTAL MAGNESIUM	1343.00	UG/L	216.00	X	83.95	X	Y
MSFC-039	97Q4	TOTAL MAGNESIUM	448.30	UG/L	216.00	X	83.95	X	Y
MSFC-049	97Q4	TOTAL MAGNESIUM	584.30	UG/L	216.00	X	83.95	X	Y
MSFC-021R	97Q4	TOTAL SODIUM	48379.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-033D	97Q4	TOTAL SODIUM	24442.10	UG/L	6790.00	X	20000.00	X	Y
MSFC-051D	97Q4	TOTAL SODIUM	26185.40	UG/L	6790.00	X	20000.00	X	Y
MSFC-021R	97Q4	CHLORIDE	5640.00	UG/L					N/A
MSFC-022R	97Q4	CHLORIDE	6690.00	UG/L					N/A
MSFC-025	97Q4	CHLORIDE	2060.00	UG/L					N/A
MSFC-026	97Q4	CHLORIDE	3060.00	UG/L					N/A
MSFC-029D	97Q4	CHLORIDE	2980.00	UG/L					N/A
MSFC-032	97Q4	CHLORIDE	7340.00	UG/L					N/A
MSFC-033D	97Q4	CHLORIDE	3870.00	UG/L					N/A
MSFC-034D	97Q4	CHLORIDE	11000.00	UG/L					N/A
MSFC-038	97Q4	CHLORIDE	2740.00	UG/L					N/A
MSFC-039	97Q4	CHLORIDE	6610.00	UG/L					N/A
MSFC- 047	97Q4	CHLORIDE	6950.00	UG/L					N/A
MSFC-047	97Q4	CHLORIDE	6450.00	UG/L					N/A
MSFC-049	97Q4	CHLORIDE	6110.00	UG/L					N/A
MSFC-051D	97Q4	CHLORIDE	7820.00	UG/L					N/A
MSFC-021R	97Q4	pH	7.29	s.u.					N/A
MSFC-022R	97Q4	pH	7.22	s.u.					N/A
MSFC-025	97Q4	pH	6.58	s.u.					N/A
MSFC-026	97Q4	pH	7.04	s.u.					N/A
MSFC-029D	97Q4	pH	8.06	s.u.					N/A
MSFC-032	97Q4	pH	6.70	s.u.					N/A
MSFC-033D	97Q4	pH	7.83	s.u.					N/A
MSFC-034D	97Q4	pH	7.74	s.u.					N/A
MSFC-038	97Q4	pH	5.06	s.u.					N/A
MSFC-039	97Q4	pH	7.05	s.u.					N/A
MSFC-047	97Q4	pH	7.14	s.u.					N/A
MSFC-047	97Q4	pH	7.14	s.u.					N/A
MSFC-049	97Q4	pH	8.03	s.u.					N/A
MSFC-051D	97Q4	pH	8.00	s.u.					N/A

Appendix A
Groundwater, Fourth Quarter 1997
OU-9 Record of Decision

Location	Quarter	Parameter	Concentration	Units	Comparison Criteria		Final Exceedance
					Background	Human Health	
						MCL or RBC	Y/N
MSFC-021R	97Q4	SULFATE	31730.00	UG/L			N/A
MSFC-022R	97Q4	SULFATE	3950.00	UG/L			N/A
MSFC-025	97Q4	SULFATE	14620.00	UG/L			N/A
MSFC-026	97Q4	SULFATE	36160.00	UG/L			N/A
MSFC-029D	97Q4	SULFATE	6570.00	UG/L			N/A
MSFC-032	97Q4	SULFATE	7750.00	UG/L			N/A
MSFC-033D	97Q4	SULFATE	21520.00	UG/L			N/A
MSFC-034D	97Q4	SULFATE	7820.00	UG/L			N/A
MSFC-039	97Q4	SULFATE	5140.00	UG/L			N/A
MSFC-047	97Q4	SULFATE	3990.00	UG/L			N/A
MSFC-047	97Q4	SULFATE	3700.00	UG/L			N/A
MSFC-049	97Q4	SULFATE	4460.00	UG/L			N/A
MSFC-051D	97Q4	SULFATE	55410.00	UG/L			N/A
MSFC-038	97Q4	TOTAL DISSOLVED ALUMINUM	17.50	UG/L			N/A
MSFC-021R	97Q4	TOTAL DISSOLVED BARIUM	285.50	UG/L			N/A
MSFC-022R	97Q4	TOTAL DISSOLVED BARIUM	18.20	UG/L			N/A
MSFC-025	97Q4	TOTAL DISSOLVED BARIUM	30.50	UG/L			N/A
MSFC-026	97Q4	TOTAL DISSOLVED BARIUM	48.10	UG/L			N/A
MSFC-032	97Q4	TOTAL DISSOLVED BARIUM	51.00	UG/L			N/A
MSFC-038	97Q4	TOTAL DISSOLVED BARIUM	10.70	UG/L			N/A
MSFC-039	97Q4	TOTAL DISSOLVED BARIUM	30.80	UG/L			N/A
MSFC-049	97Q4	TOTAL DISSOLVED BARIUM	61.70	UG/L			N/A
MSFC-021R	97Q4	TOTAL DISSOLVED IRON	14390.10	UG/L			N/A
MSFC-022R	97Q4	TOTAL DISSOLVED IRON	121.00	UG/L			N/A
MSFC-025	97Q4	TOTAL DISSOLVED IRON	126.70	UG/L			N/A
MSFC-026	97Q4	TOTAL DISSOLVED IRON	119.00	UG/L			N/A
MSFC-032	97Q4	TOTAL DISSOLVED IRON	3269.40	UG/L			N/A
MSFC-038	97Q4	TOTAL DISSOLVED IRON	128.60	UG/L			N/A
MSFC-039	97Q4	TOTAL DISSOLVED IRON	269.00	UG/L			N/A
MSFC-049	97Q4	TOTAL DISSOLVED IRON	163.10	UG/L			N/A
MSFC-021R	97Q4	TOTAL DISSOLVED MAGNESIUM	8451.40	UG/L			N/A
MSFC-022R	97Q4	TOTAL DISSOLVED MAGNESIUM	5546.30	UG/L			N/A
MSFC-025	97Q4	TOTAL DISSOLVED MAGNESIUM	4774.10	UG/L			N/A
MSFC-026	97Q4	TOTAL DISSOLVED MAGNESIUM	7718.10	UG/L			N/A
MSFC-032	97Q4	TOTAL DISSOLVED MAGNESIUM	3809.20	UG/L			N/A
MSFC-038	97Q4	TOTAL DISSOLVED MAGNESIUM	794.10	UG/L			N/A
MSFC-039	97Q4	TOTAL DISSOLVED MAGNESIUM	10845.40	UG/L			N/A
MSFC-049	97Q4	TOTAL DISSOLVED MAGNESIUM	8391.40	UG/L			N/A
MSFC-021R	97Q4	TOTAL DISSOLVED MANGANESE	4032.20	UG/L			N/A
MSFC-026	97Q4	TOTAL DISSOLVED MANGANESE	32.80	UG/L			N/A
MSFC-032	97Q4	TOTAL DISSOLVED MANGANESE	1323.40	UG/L			N/A
MSFC-038	97Q4	TOTAL DISSOLVED MANGANESE	38.10	UG/L			N/A
MSFC-039	97Q4	TOTAL DISSOLVED MANGANESE	353.00	UG/L			N/A
MSFC-049	97Q4	TOTAL DISSOLVED MANGANESE	575.90	UG/L			N/A
MSFC-021	97Q4	TOTAL DISSOLVED POTASSIUM	3264.30	UG/L			N/A

Appendix A
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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-022R	97Q4	TOTAL DISSOLVED POTASSIUM	623.40	UG/L					N/A
MSFC-025	97Q4	TOTAL DISSOLVED POTASSIUM	2917.20	UG/L					N/A
MSFC-026	97Q4	TOTAL DISSOLVED POTASSIUM	1799.80	UG/L					N/A
MSFC-032	97Q4	TOTAL DISSOLVED POTASSIUM	532.30	UG/L					N/A
MSFC-038	97Q4	TOTAL DISSOLVED POTASSIUM	322.60	UG/L					N/A
MSFC-039	97Q4	TOTAL DISSOLVED POTASSIUM	453.50	UG/L					N/A
MSFC-049	97Q4	TOTAL DISSOLVED POTASSIUM	506.50	UG/L					N/A
MSFC-021R	97Q4	TOTAL DISSOLVED SODIUM	48152.10	UG/L					N/A
MSFC-022R	97Q4	TOTAL DISSOLVED SODIUM	3316.50	UG/L					N/A
MSFC-025	97Q4	TOTAL DISSOLVED SODIUM	3609.00	UG/L					N/A
MSFC-026	97Q4	TOTAL DISSOLVED SODIUM	5240.80	UG/L					N/A
MSFC-032	97Q4	TOTAL DISSOLVED SODIUM	7905.20	UG/L					N/A
MSFC-038	97Q4	TOTAL DISSOLVED SODIUM	1219.50	UG/L					N/A
MSFC-039	97Q4	TOTAL DISSOLVED SODIUM	3647.60	UG/L					N/A
MSFC-049	97Q4	TOTAL DISSOLVED SODIUM	10125.80	UG/L					N/A
MSFC-021R	97Q4	TOTAL DISSOLVED SOLIDS	286000.00	UG/L					N/A
MSFC-022R	97Q4	TOTAL DISSOLVED SOLIDS	198000.00	UG/L					N/A
MSFC-025	97Q4	TOTAL DISSOLVED SOLIDS	142000.00	UG/L					N/A
MSFC-026	97Q4	TOTAL DISSOLVED SOLIDS	205000.00	UG/L					N/A
MSFC-029D	97Q4	TOTAL DISSOLVED SOLIDS	184000.00	UG/L					N/A
MSFC-032	97Q4	TOTAL DISSOLVED SOLIDS	152000.00	UG/L					N/A
MSFC-033D	97Q4	TOTAL DISSOLVED SOLIDS	244000.00	UG/L					N/A
MSFC-034D	97Q4	TOTAL DISSOLVED SOLIDS	189000.00	UG/L					N/A
MSFC-038	97Q4	TOTAL DISSOLVED SOLIDS	16000.00	UG/L					N/A
MSFC-039	97Q4	TOTAL DISSOLVED SOLIDS	185000.00	UG/L					N/A
MSFC-047	97Q4	TOTAL DISSOLVED SOLIDS	208000.00	UG/L					N/A
MSFC-047	97Q4	TOTAL DISSOLVED SOLIDS	206000.00	UG/L					N/A
MSFC-049	97Q4	TOTAL DISSOLVED SOLIDS	263000.00	UG/L					N/A
MSFC-051D	97Q4	TOTAL DISSOLVED SOLIDS	238000.00	UG/L					N/A
MSFC-021R	97Q4	TOTAL POTASSIUM	3237.90	UG/L	2620.00	X			N/A
MSFC-025	97Q4	TOTAL POTASSIUM	3001.70	UG/L	2620.00	X			N/A
MSFC-021R	97Q4	TURBIDITY	5.37	ntu					N/A
MSFC-022R	97Q4	TURBIDITY	1.21	ntu					N/A
MSFC-025	97Q4	TURBIDITY	8.86	ntu					N/A
MSFC-026	97Q4	TURBIDITY	1.25	ntu					N/A
MSFC-029D	97Q4	TURBIDITY	27.10	ntu					N/A
MSFC-032	97Q4	TURBIDITY	76.90	ntu					N/A
MSFC-033D	97Q4	TURBIDITY	6.55	ntu					N/A
MSFC-034D	97Q4	TURBIDITY	1.43	ntu					N/A
MSFC-038	97Q4	TURBIDITY	12.90	ntu					N/A
MSFC-039	97Q4	TURBIDITY	4.11	ntu					N/A
MSFC-047	97Q4	TURBIDITY	0.24	ntu					N/A
MSFC-047	97Q4	TURBIDITY	0.24	ntu					N/A
MSFC-049	97Q4	TURBIDITY	1.78	ntu					N/A
MSFC-051	97Q4	TURBIDITY	6.58	ntu					N/A

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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-021R	97Q4	CIS-1,2 DICHLOROETHENE	8.90	UG/L			70.00		N
MSFC-021R	97Q4	TOTAL ALUMINUM	13.50	UG/L	2970.00		200.00		N
MSFC-022R	97Q4	TOTAL ALUMINUM	20.40	UG/L	2970.00		200.00		N
MSFC-025	97Q4	TOTAL ALUMINUM	75.00	UG/L	2970.00		200.00		N
MSFC-029D	97Q4	TOTAL ALUMINUM	42.60	UG/L	2970.00		200.00		N
MSFC-032	97Q4	TOTAL ALUMINUM	118.00	UG/L	2970.00		200.00		N
MSFC-033D	97Q4	TOTAL ALUMINUM	69.50	UG/L	2970.00		200.00		N
MSFC-034D	97Q4	TOTAL ALUMINUM	20.40	UG/L	2970.00		200.00		N
MSFC-038	97Q4	TOTAL ALUMINUM	545.40	UG/L	2970.00		200.00	X	N
MSFC-039	97Q4	TOTAL ALUMINUM	73.70	UG/L	2970.00		200.00		N
MSFC-049	97Q4	TOTAL ALUMINUM	17.80	UG/L	2970.00		200.00		N
MSFC-021R	97Q4	TOTAL BARIUM	289.40	UG/L	41.30	X	2000.00		N
MSFC-022R	97Q4	TOTAL BARIUM	17.70	UG/L	41.30		2000.00		N
MSFC-025	97Q4	TOTAL BARIUM	31.80	UG/L	41.30		2000.00		N
MSFC-026	97Q4	TOTAL BARIUM	48.50	UG/L	41.30	X	2000.00		N
MSFC-029D	97Q4	TOTAL BARIUM	21.40	UG/L	41.30		2000.00		N
MSFC-032	97Q4	TOTAL BARIUM	53.20	UG/L	41.30	X	2000.00		N
MSFC-033D	97Q4	TOTAL BARIUM	50.20	UG/L	41.30	X	2000.00		N
MSFC-034D	97Q4	TOTAL BARIUM	40.60	UG/L	41.30		2000.00		N
MSFC-038	97Q4	TOTAL BARIUM	11.30	UG/L	41.30		2000.00		N
MSFC-039	97Q4	TOTAL BARIUM	32.30	UG/L	41.30		2000.00		N
MSFC-047	97Q4	TOTAL BARIUM	15.10	UG/L	41.30		2000.00		N
MSFC-047	97Q4	TOTAL BARIUM	15.10	UG/L	41.30		2000.00		N
MSFC-049	97Q4	TOTAL BARIUM	62.00	UG/L	41.30	X	2000.00		N
MSFC-051D	97Q4	TOTAL BARIUM	22.50	UG/L	41.30		2000.00		N
MSFC-022R	97Q4	TOTAL IRON	131.80	UG/L	4640.00		11000.00		N
MSFC-025	97Q4	TOTAL IRON	144.80	UG/L	4640.00		11000.00		N
MSFC-026	97Q4	TOTAL IRON	122.00	UG/L	4640.00		11000.00		N
MSFC-029D	97Q4	TOTAL IRON	182.50	UG/L	4640.00		11000.00		N
MSFC-032	97Q4	TOTAL IRON	3979.40	UG/L	4640.00		11000.00		N
MSFC-033D	97Q4	TOTAL IRON	185.30	UG/L	4640.00		11000.00		N
MSFC-034D	97Q4	TOTAL IRON	149.90	UG/L	4640.00		11000.00		N
MSFC-038	97Q4	TOTAL IRON	461.90	UG/L	4640.00		11000.00		N
MSFC-039	97Q4	TOTAL IRON	622.10	UG/L	4640.00		11000.00		N
MSFC-047	97Q4	TOTAL IRON	115.40	UG/L	4640.00		11000.00		N
MSFC-047	97Q4	TOTAL IRON	121.70	UG/L	4640.00		11000.00		N
MSFC-049	97Q4	TOTAL IRON	296.00	UG/L	4640.00		11000.00		N
MSFC-051D	97Q4	TOTAL IRON	166.40	UG/L	4640.00		11000.00		N
MSFC-022R	97Q4	TOTAL MAGNESIUM	5704.40	UG/L	7220.00		50.00	X	N
MSFC-025	97Q4	TOTAL MAGNESIUM	4904.20	UG/L	7220.00		50.00	X	N
MSFC-032	97Q4	TOTAL MAGNESIUM	4012.10	UG/L	7220.00		50.00	X	N
MSFC-038	97Q4	TOTAL MAGNESIUM	832.50	UG/L	7220.00		50.00	X	N
MSFC-047	97Q4	TOTAL MAGNESIUM	7160.70	UG/L	7220.00		50.00	X	N
MSFC-026	97Q4	TOTAL MANGANESE	33.80	UG/L	216.00		83.95		N
MSFC-029D	97Q4	TOTAL MANGANESE	11.60	UG/L	216.00		83.95		N

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					Background		Human Health		
							MCL or RBC		
MSFC-033D	97Q4	TOTAL MANGANESE	24.70	UG/L	216.00		83.95		N
MSFC-034D	97Q4	TOTAL MANGANESE	10.40	UG/L	216.00		83.95		N
MSFC-038	97Q4	TOTAL MANGANESE	65.50	UG/L	216.00		83.95		N
MSFC-029D	97Q4	TOTAL NICKEL	10.70	UG/L	35.40		100.00		N
MSFC-033D	97Q4	TOTAL NICKEL	10.30	UG/L	35.40		100.00		N
MSFC-034D	97Q4	TOTAL NICKEL	13.20	UG/L	35.40		100.00		N
MSFC-022R	97Q4	TOTAL POTASSIUM	623.30	UG/L	2620.00				N
MSFC-026	97Q4	TOTAL POTASSIUM	1824.00	UG/L	2620.00				N
MSFC-029D	97Q4	TOTAL POTASSIUM	951.20	UG/L	2620.00				N
MSFC-032	97Q4	TOTAL POTASSIUM	574.80	UG/L	2620.00				N
MSFC-033D	97Q4	TOTAL POTASSIUM	1789.10	UG/L	2620.00				N
MSFC-034D	97Q4	TOTAL POTASSIUM	451.10	UG/L	2620.00				N
MSFC-038	97Q4	TOTAL POTASSIUM	435.90	UG/L	2620.00				N
MSFC-039	97Q4	TOTAL POTASSIUM	478.60	UG/L	2620.00				N
MSFC-047	97Q4	TOTAL POTASSIUM	679.20	UG/L	2620.00				N
MSFC-047	97Q4	TOTAL POTASSIUM	698.80	UG/L	2620.00				N
MSFC-049	97Q4	TOTAL POTASSIUM	523.20	UG/L	2620.00				N
MSFC-051D	97Q4	TOTAL POTASSIUM	983.20	UG/L	2620.00				N
MSFC-022R	97Q4	TOTAL SODIUM	3330.30	UG/L	6790.00		20000.00		N
MSFC-025	97Q4	TOTAL SODIUM	3768.70	UG/L	6790.00		20000.00		N
MSFC-026	97Q4	TOTAL SODIUM	5283.00	UG/L	6790.00		20000.00		N
MSFC-029D	97Q4	TOTAL SODIUM	4895.50	UG/L	6790.00		20000.00		N
MSFC-032	97Q4	TOTAL SODIUM	8203.00	UG/L	6790.00	X	20000.00		N
MSFC-034D	97Q4	TOTAL SODIUM	2668.50	UG/L	6790.00		20000.00		N
MSFC-038	97Q4	TOTAL SODIUM	1216.20	UG/L	6790.00		20000.00		N
MSFC-039	97Q4	TOTAL SODIUM	4023.20	UG/L	6790.00		20000.00		N
MSFC-047	97Q4	TOTAL SODIUM	3696.50	UG/L	6790.00		20000.00		N
MSFC-047	97Q4	TOTAL SODIUM	3774.70	UG/L	6790.00		20000.00		N
MSFC-049	97Q4	TOTAL SODIUM	10414.40	UG/L	6790.00		20000.00		N

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					Background		Human Health		
							MCL or RBC		
MSFC-021R	98Q1	TOTAL IRON	19030.00	UG/L	4640.00	X	11000.00	X	Y
MSFC-021R	98Q1	TOTAL MAGNESIUM	8897.00	UG/L	7220.00	X	50.00	X	Y
MSFC-029D	98Q1	TOTAL MAGNESIUM	22268.00	UG/L	7220.00	X	50.00	X	Y
MSFC-033D	98Q1	TOTAL MAGNESIUM	212139.00	UG/L	7220.00	X	50.00	X	Y
MSFC-034D	98Q1	TOTAL MAGNESIUM	18457.00	UG/L	7220.00	X	50.00	X	Y
MSFC-039	98Q1	TOTAL MAGNESIUM	10631.00	UG/L	7220.00	X	50.00	X	Y
MSFC-047	98Q1	TOTAL MAGNESIUM	7344.00	UG/L	7220.00	X	50.00	X	Y
MSFC-049	98Q1	TOTAL MAGNESIUM	7888.00	UG/L	7220.00	X	50.00	X	Y
MSFC-051D	98Q1	TOTAL MAGNESIUM	18515.00	UG/L	7220.00	X	50.00	X	Y
MSFC-021R	98Q1	TOTAL MANGANESE	5659.00	UG/L	216.00	X	83.95	X	Y
MSFC-032	98Q1	TOTAL MANGANESE	1144.00	UG/L	216.00	X	83.95	X	Y
MSFC-039	98Q1	TOTAL MANGANESE	516.00	UG/L	216.00	X	83.95	X	Y
MSFC-049	98Q1	TOTAL MANGANESE	2696.00	UG/L	216.00	X	83.95	X	Y
MSFC-021R	98Q1	TOTAL SODIUM	36851.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-033D	98Q1	TOTAL SODIUM	28345.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-051D	98Q1	TOTAL SODIUM	24887.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-021R	98Q1	CHLORIDE	2460.00	UG/L					N/A
MSFC-022R	98Q1	CHLORIDE	5730.00	UG/L					N/A
MSFC-025	98Q1	CHLORIDE	1480.00	UG/L					N/A
MSFC-026	98Q1	CHLORIDE	2050.00	UG/L					N/A
MSFC-029D	98Q1	CHLORIDE	1260.00	UG/L					N/A
MSFC-032	98Q1	CHLORIDE	3420.00	UG/L					N/A
MSFC-033D	98Q1	CHLORIDE	2410.00	UG/L					N/A
MSFC-034D	98Q1	CHLORIDE	10140.00	UG/L					N/A
MSFC-038	98Q1	CHLORIDE	2540.00	UG/L					N/A
MSFC-039	98Q1	CHLORIDE	5430.00	UG/L					N/A
MSFC-047	98Q1	CHLORIDE	5440.00	UG/L					N/A
MSFC-049	98Q1	CHLORIDE	5560.00	UG/L					N/A
MSFC-051D	98Q1	CHLORIDE	6470.00	UG/L					N/A
MSFC-021R	98Q1	SULFATE	7900.00	UG/L					N/A
MSFC-022R	98Q1	SULFATE	4640.00	UG/L					N/A
MSFC-025	98Q1	SULFATE	14910.00	UG/L					N/A
MSFC-026	98Q1	SULFATE	32570.00	UG/L					N/A
MSFC-029D	98Q1	SULFATE	4060.00	UG/L					N/A
MSFC-032	98Q1	SULFATE	9700.00	UG/L					N/A
MSFC-033D	98Q1	SULFATE	8250.00	UG/L					N/A
MSFC-034D	98Q1	SULFATE	7900.00	UG/L					N/A
MSFC-039	98Q1	SULFATE	5250.00	UG/L					N/A
MSFC-047	98Q1	SULFATE	3950.00	UG/L					N/A
MSFC-049	98Q1	SULFATE	8120.00	UG/L					N/A
MSFC-051D	98Q1	SULFATE	67390.00	UG/L					N/A
MSFC-038	98Q1	TOTAL DISSOLVED ALUMINUM	14.00	UG/L					N/A
MSFC-021R	98Q1	TOTAL DISSOLVED BARIUM	220.00	UG/L					N/A
MSFC-022R	98Q1	TOTAL DISSOLVED BARIUM	18.00	UG/L					N/A
MSFC-025	98Q1	TOTAL DISSOLVED BARIUM	26.00	UG/L					N/A

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					Background	Human Health MCL or RBC	
MSFC-026	98Q1	TOTAL DISSOLVED BARIUM	34.00	UG/L			N/A
MSFC-032	98Q1	TOTAL DISSOLVED BARIUM	39.00	UG/L			N/A
MSFC-039	98Q1	TOTAL DISSOLVED BARIUM	39.00	UG/L			N/A
MSFC-049	98Q1	TOTAL DISSOLVED BARIUM	71.00	UG/L			N/A
MSFC-021R	98Q1	TOTAL DISSOLVED IRON	18630.00	UG/L			N/A
MSFC-022R	98Q1	TOTAL DISSOLVED IRON	60.00	UG/L			N/A
MSFC-025	98Q1	TOTAL DISSOLVED IRON	68.00	UG/L			N/A
MSFC-026	98Q1	TOTAL DISSOLVED IRON	69.00	UG/L			N/A
MSFC-032	98Q1	TOTAL DISSOLVED IRON	3345.00	UG/L			N/A
MSFC-038	98Q1	TOTAL DISSOLVED IRON	87.00	UG/L			N/A
MSFC-039	98Q1	TOTAL DISSOLVED IRON	360.00	UG/L			N/A
MSFC-049	98Q1	TOTAL DISSOLVED IRON	1329.00	UG/L			N/A
MSFC-021R	98Q1	TOTAL DISSOLVED MAGNESIUM	8560.00	UG/L			N/A
MSFC-022R	98Q1	TOTAL DISSOLVED MAGNESIUM	5355.00	UG/L			N/A
MSFC-025	98Q1	TOTAL DISSOLVED MAGNESIUM	4476.00	UG/L			N/A
MSFC-026	98Q1	TOTAL DISSOLVED MAGNESIUM	6409.00	UG/L			N/A
MSFC-032	98Q1	TOTAL DISSOLVED MAGNESIUM	3406.00	UG/L			N/A
MSFC-038	98Q1	TOTAL DISSOLVED MAGNESIUM	800.00	UG/L			N/A
MSFC-039	98Q1	TOTAL DISSOLVED MAGNESIUM	10159.00	UG/L			N/A
MSFC-049	98Q1	TOTAL DISSOLVED MAGNESIUM	7985.00	UG/L			N/A
MSFC-021R	98Q1	TOTAL DISSOLVED MANGANESE	5149.00	UG/L			N/A
MSFC-026	98Q1	TOTAL DISSOLVED MANGANESE	30.00	UG/L			N/A
MSFC-032	98Q1	TOTAL DISSOLVED MANGANESE	1149.00	UG/L			N/A
MSFC-038	98Q1	TOTAL DISSOLVED MANGANESE	28.00	UG/L			N/A
MSFC-039	98Q1	TOTAL DISSOLVED MANGANESE	433.00	UG/L			N/A
MSFC-049	98Q1	TOTAL DISSOLVED MANGANESE	2683.00	UG/L			N/A
MSFC-021R	98Q1	TOTAL DISSOLVED POTASSIUM	2402.00	UG/L			N/A
MSFC-022R	98Q1	TOTAL DISSOLVED POTASSIUM	589.00	UG/L			N/A
MSFC-025	98Q1	TOTAL DISSOLVED POTASSIUM	2454.00	UG/L			N/A
MSFC-026	98Q1	TOTAL DISSOLVED POTASSIUM	1286.00	UG/L			N/A
MSFC-032	98Q1	TOTAL DISSOLVED POTASSIUM	374.00	UG/L			N/A
MSFC-038	98Q1	TOTAL DISSOLVED POTASSIUM	329.00	UG/L			N/A
MSFC-039	98Q1	TOTAL DISSOLVED POTASSIUM	417.00	UG/L			N/A
MSFC-049	98Q1	TOTAL DISSOLVED POTASSIUM	304.00	UG/L			N/A
MSFC-021R	98Q1	TOTAL DISSOLVED SODIUM	35290.00	UG/L			N/A
MSFC-022R	98Q1	TOTAL DISSOLVED SODIUM	3728.00	UG/L			N/A
MSFC-025	98Q1	TOTAL DISSOLVED SODIUM	2918.00	UG/L			N/A
MSFC-026	98Q1	TOTAL DISSOLVED SODIUM	4848.00	UG/L			N/A
MSFC-032	98Q1	TOTAL DISSOLVED SODIUM	6642.00	UG/L			N/A
MSFC-038	98Q1	TOTAL DISSOLVED SODIUM	1288.00	UG/L			N/A
MSFC-039	98Q1	TOTAL DISSOLVED SODIUM	4570.00	UG/L			N/A
MSFC-049	98Q1	TOTAL DISSOLVED SODIUM	14609.00	UG/L			N/A
MSFC-021R	98Q1	TOTAL DISSOLVED SOLIDS	274000.00	UG/L			N/A
MSFC-022R	98Q1	TOTAL DISSOLVED SOLIDS	219000.00	UG/L			N/A
MSFC-025	98Q1	TOTAL DISSOLVED SOLIDS	139000.00	UG/L			N/A

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					Background		Human Health		
							MCL or RBC		
MSFC-026	98Q1	TOTAL DISSOLVED SOLIDS	171000.00	UG/L					N/A
MSFC-029D	98Q1	TOTAL DISSOLVED SOLIDS	187000.00	UG/L					N/A
MSFC-032	98Q1	TOTAL DISSOLVED SOLIDS	145000.00	UG/L					N/A
MSFC-033D	98Q1	TOTAL DISSOLVED SOLIDS	214000.00	UG/L					N/A
MSFC-034D	98Q1	TOTAL DISSOLVED SOLIDS	202000.00	UG/L					N/A
MSFC-038	98Q1	TOTAL DISSOLVED SOLIDS	33000.00	UG/L					N/A
MSFC-039	98Q1	TOTAL DISSOLVED SOLIDS	198000.00	UG/L					N/A
MSFC-047	98Q1	TOTAL DISSOLVED SOLIDS	212000.00	UG/L					N/A
MSFC-049	98Q1	TOTAL DISSOLVED SOLIDS	300000.00	UG/L					N/A
MSFC-051D	98Q1	TOTAL DISSOLVED SOLIDS	253000.00	UG/L					N/A
MSFC-022R	98Q1	TOTAL ALUMINUM	30.00	UG/L	2970.00		200.00		N
MSFC-025	98Q1	TOTAL ALUMINUM	106.00	UG/L	2970.00		200.00		N
MSFC-026	98Q1	TOTAL ALUMINUM	12.00	UG/L	2970.00		200.00		N
MSFC-032	98Q1	TOTAL ALUMINUM	90.00	UG/L	2970.00		200.00		N
MSFC-033D	98Q1	TOTAL ALUMINUM	139.00	UG/L	2970.00		200.00		N
MSFC-038	98Q1	TOTAL ALUMINUM	532.00	UG/L	2970.00		200.00	X	N
MSFC-039	98Q1	TOTAL ALUMINUM	28.00	UG/L	2970.00		200.00		N
MSFC-049	98Q1	TOTAL ALUMINUM	66.00	UG/L	2970.00		200.00		N
MSFC-021R	98Q1	TOTAL BARIUM	277.00	UG/L	41.30	X	2000.00		N
MSFC-022R	98Q1	TOTAL BARIUM	18.00	UG/L	41.30		2000.00		N
MSFC-025	98Q1	TOTAL BARIUM	28.00	UG/L	41.30		2000.00		N
MSFC-026	98Q1	TOTAL BARIUM	34.00	UG/L	41.30		2000.00		N
MSFC-029D	98Q1	TOTAL BARIUM	21.00	UG/L	41.30		2000.00		N
MSFC-032	98Q1	TOTAL BARIUM	40.00	UG/L	41.30		2000.00		N
MSFC-033D	98Q1	TOTAL BARIUM	57.00	UG/L	41.30	X	2000.00		N
MSFC-034D	98Q1	TOTAL BARIUM	35.00	UG/L	41.30		2000.00		N
MSFC-039	98Q1	TOTAL BARIUM	42.00	UG/L	41.30	X	2000.00		N
MSFC-047	98Q1	TOTAL BARIUM	15.00	UG/L	41.30		2000.00		N
MSFC-049	98Q1	TOTAL BARIUM	73.00	UG/L	41.30	X	2000.00		N
MSFC-051D	98Q1	TOTAL BARIUM	22.00	UG/L	41.30		2000.00		N
MSFC-022R	98Q1	TOTAL IRON	122.00	UG/L	4640.00		11000.00		N
MSFC-025	98Q1	TOTAL IRON	104.00	UG/L	4640.00		11000.00		N
MSFC-026	98Q1	TOTAL IRON	78.00	UG/L	4640.00		11000.00		N
MSFC-029D	98Q1	TOTAL IRON	110.00	UG/L	4640.00		11000.00		N
MSFC-032	98Q1	TOTAL IRON	3392.00	UG/L	4640.00		11000.00		N
MSFC-033D	98Q1	TOTAL IRON	242.00	UG/L	4640.00		11000.00		N
MSFC-034D	98Q1	TOTAL IRON	83.00	UG/L	4640.00		11000.00		N
MSFC-038	98Q1	TOTAL IRON	396.00	UG/L	4640.00		11000.00		N
MSFC-039	98Q1	TOTAL IRON	665.00	UG/L	4640.00		11000.00		N
MSFC-047	98Q1	TOTAL IRON	61.00	UG/L	4640.00		11000.00		N
MSFC-049	98Q1	TOTAL IRON	2270.00	UG/L	4640.00		11000.00		N
MSFC-051D	98Q1	TOTAL IRON	53.00	UG/L	4640.00		11000.00		N
MSFC-022R	98Q1	TOTAL MAGNESIUM	5336.00	UG/L	7220.00		50.00	X	N
MSFC-025	98Q1	TOTAL MAGNESIUM	4734.00	UG/L	7220.00		50.00	X	N
MSFC-026	98Q1	TOTAL MAGNESIUM	6528.00	UG/L	7220.00		50.00	X	N

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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-032	98Q1	TOTAL MAGNESIUM	3459.00	UG/L	7200.00		50.00	X	N
MSFC-038	98Q1	TOTAL MAGNESIUM	843.00	UG/L	7200.00		50.00	X	N
MSFC-025	98Q1	TOTAL MANGANESE	19.00	UG/L	216.00		83.95		N
MSFC-026	98Q1	TOTAL MANGANESE	36.00	UG/L	216.00		83.95		N
MSFC-029D	98Q1	TOTAL MANGANESE	25.00	UG/L	216.00		83.95		N
MSFC-033D	98Q1	TOTAL MANGANESE	29.00	UG/L	216.00		83.95		N
MSFC-034D	98Q1	TOTAL MANGANESE	21.00	UG/L	216.00		83.95		N
MSFC-038	98Q1	TOTAL MANGANESE	62.00	UG/L	216.00		83.95		N
MSFC-021R	98Q1	TOTAL NICKEL	19.00	UG/L	35.40		100.00		N
MSFC-021R	98Q1	TOTAL POTASSIUM	2504.00	UG/L	2620.00				N
MSFC-022R	98Q1	TOTAL POTASSIUM	573.00	UG/L	2620.00				N
MSFC-025	98Q1	TOTAL POTASSIUM	2549.00	UG/L	2620.00				N
MSFC-026	98Q1	TOTAL POTASSIUM	1288.00	UG/L	2620.00				N
MSFC-029D	98Q1	TOTAL POTASSIUM	1771.00	UG/L	2620.00				N
MSFC-032	98Q1	TOTAL POTASSIUM	386.00	UG/L	2620.00				N
MSFC-033D	98Q1	TOTAL POTASSIUM	2016.00	UG/L	2620.00				N
MSFC-034D	98Q1	TOTAL POTASSIUM	410.00	UG/L	2620.00				N
MSFC-038	98Q1	TOTAL POTASSIUM	374.00	UG/L	2620.00				N
MSFC-039	98Q1	TOTAL POTASSIUM	444.00	UG/L	2620.00				N
MSFC-047	98Q1	TOTAL POTASSIUM	697.00	UG/L	2620.00				N
MSFC-049	98Q1	TOTAL POTASSIUM	309.00	UG/L	2620.00				N
MSFC-051D	98Q1	TOTAL POTASSIUM	938.00	UG/L	2620.00				N
MSFC-022R	98Q1	TOTAL SODIUM	3708.00	UG/L	6790.00		20000.00		N
MSFC-025	98Q1	TOTAL SODIUM	3085.00	UG/L	6790.00		20000.00		N
MSFC-026	98Q1	TOTAL SODIUM	4850.00	UG/L	6790.00		20000.00		N
MSFC-029D	98Q1	TOTAL SODIUM	5693.00	UG/L	6790.00		20000.00		N
MSFC-032	98Q1	TOTAL SODIUM	6668.00	UG/L	6790.00		20000.00		N
MSFC-034D	98Q1	TOTAL SODIUM	2394.00	UG/L	6790.00		20000.00		N
MSFC-038	98Q1	TOTAL SODIUM	1305.00	UG/L	6790.00		20000.00		N
MSFC-039	98Q1	TOTAL SODIUM	4808.00	UG/L	6790.00		20000.00		N
MSFC-047	98Q1	TOTAL SODIUM	4078.00	UG/L	6790.00		20000.00		N
MSFC-049	98Q1	TOTAL SODIUM	14797.00	UG/L	6790.00	X	20000.00		N

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					Background		Human Health		
							MCL or RBC		
MSFC-021R	98Q2	TOTAL IRON	23998.00	UG/L	4640.00	X	11000.00	X	Y
MSFC-029D	98Q2	TOTAL LEAD	5034.00	UG/L	3.70	X	15.00	X	Y
MSFC-021R	98Q2	TOTAL MAGNESIUM	7988.00	UG/L	7220.00	X	50.00	X	Y
MSFC-033D	98Q2	TOTAL MAGNESIUM	19922.00	UG/L	7220.00	X	50.00	X	Y
MSFC-034D	98Q2	TOTAL MAGNESIUM	17614.00	UG/L	7220.00	X	50.00	X	Y
MSFC-039	98Q2	TOTAL MAGNESIUM	10356.00	UG/L	7220.00	X	50.00	X	Y
MSFC-051D	98Q2	TOTAL MAGNESIUM	18632.00	UG/L	7220.00	X	50.00	X	Y
MSFC-021R	98Q2	TOTAL MANGANESE	3870.00	UG/L	216.00	X	83.95	X	Y
MSFC-032	98Q2	TOTAL MANGANESE	797.00	UG/L	216.00	X	83.95	X	Y
MSFC-039	98Q2	TOTAL MANGANESE	471.00	UG/L	216.00	X	83.95	X	Y
MSFC-049	98Q2	TOTAL MANGANESE	58333.00	UG/L	216.00	X	83.95	X	Y
MSFC-021R	98Q2	TOTAL SODIUM	36505.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-033D	98Q2	TOTAL SODIUM	22831.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-051D	98Q2	TOTAL SODIUM	24490.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-021R	98Q2	CHLORIDE	2220.00	UG/L					N/A
MSFC-022R	98Q2	CHLORIDE	4870.00	UG/L					N/A
MSFC-025	98Q2	CHLORIDE	1200.00	UG/L					N/A
MSFC-026	98Q2	CHLORIDE	1520.00	UG/L					N/A
MSFC-029D	98Q2	CHLORIDE	1010.00	UG/L					N/A
MSFC-032	98Q2	CHLORIDE	2770.00	UG/L					N/A
MSFC-033D	98Q2	CHLORIDE	2110.00	UG/L					N/A
MSFC-034D	98Q2	CHLORIDE	9730.00	UG/L					N/A
MSFC-038	98Q2	CHLORIDE	2130.00	UG/L					N/A
MSFC-039	98Q2	CHLORIDE	4960.00	UG/L					N/A
MSFC-047	98Q2	CHLORIDE	5080.00	UG/L					N/A
MSFC-049	98Q2	CHLORIDE	4930.00	UG/L					N/A
MSFC-051D	98Q2	CHLORIDE	5990.00	UG/L					N/A
MSFC-021R	98Q2	SULFATE	7550.00	UG/L					N/A
MSFC-022R	98Q2	SULFATE	3920.00	UG/L					N/A
MSFC-025	98Q2	SULFATE	4960.00	UG/L					N/A
MSFC-026	98Q2	SULFATE	37600.00	UG/L					N/A
MSFC-029D	98Q2	SULFATE	3440.00	UG/L					N/A
MSFC-032	98Q2	SULFATE	8920.00	UG/L					N/A
MSFC-033D	98Q2	SULFATE	6970.00	UG/L					N/A
MSFC-034D	98Q2	SULFATE	7790.00	UG/L					N/A
MSFC-038	98Q2	SULFATE	180.00	UG/L					N/A
MSFC-039	98Q2	SULFATE	5120.00	UG/L					N/A
MSFC-047	98Q2	SULFATE	3960.00	UG/L					N/A
MSFC-049	98Q2	SULFATE	3810.00	UG/L					N/A
MSFC-051D	98Q2	SULFATE	71920.00	UG/L					N/A
MSFC-029D	98Q2	TOTAL DISSOLVED ALUMINUM	18.00	UG/L					N/A
MSFC-021R	98Q2	TOTAL DISSOLVED BARIUM	280.00	UG/L					N/A
MSFC-022R	98Q2	TOTAL DISSOLVED BARIUM	16.00	UG/L					N/A
MSFC-025	98Q2	TOTAL DISSOLVED BARIUM	30.00	UG/L					N/A
MSFC-026	98Q2	TOTAL DISSOLVED BARIUM	37.00	UG/L					N/A

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					Background	Human Health	
						MCL or RBC	Y/N
MSFC-032	98Q2	TOTAL DISSOLVED BARIUM	40.00	UG/L			N/A
MSFC-039	98Q2	TOTAL DISSOLVED BARIUM	33.00	UG/L			N/A
MSFC-049	98Q2	TOTAL DISSOLVED BARIUM	53.00	UG/L			N/A
MSFC-029D	98Q2	TOTAL DISSOLVED CADMIUM	38.00	UG/L			N/A
MSFC-029D	98Q2	TOTAL DISSOLVED CHROMIUM	3465.00	UG/L			N/A
MSFC-021R	98Q2	TOTAL DISSOLVED IRON	16735.00	UG/L			N/A
MSFC-022R	98Q2	TOTAL DISSOLVED IRON	24.00	UG/L			N/A
MSFC-025	98Q2	TOTAL DISSOLVED IRON	51.00	UG/L			N/A
MSFC-026	98Q2	TOTAL DISSOLVED IRON	35.00	UG/L			N/A
MSFC-029D	98Q2	TOTAL DISSOLVED IRON	1579.00	UG/L			N/A
MSFC-032	98Q2	TOTAL DISSOLVED IRON	2047.00	UG/L			N/A
MSFC-038	98Q2	TOTAL DISSOLVED IRON	36.00	UG/L			N/A
MSFC-039	98Q2	TOTAL DISSOLVED IRON	331.00	UG/L			N/A
MSFC-049	98Q2	TOTAL DISSOLVED IRON	155.00	UG/L			N/A
MSFC-021R	98Q2	TOTAL DISSOLVED MAGNESIUM	7966.00	UG/L			N/A
MSFC-022R	98Q2	TOTAL DISSOLVED MAGNESIUM	5224.00	UG/L			N/A
MSFC-025	98Q2	TOTAL DISSOLVED MAGNESIUM	4990.00	UG/L			N/A
MSFC-026	98Q2	TOTAL DISSOLVED MAGNESIUM	6677.00	UG/L			N/A
MSFC-032	98Q2	TOTAL DISSOLVED MAGNESIUM	3344.00	UG/L			N/A
MSFC-038	98Q2	TOTAL DISSOLVED MAGNESIUM	697.00	UG/L			N/A
MSFC-039	98Q2	TOTAL DISSOLVED MAGNESIUM	10002.00	UG/L			N/A
MSFC-049	98Q2	TOTAL DISSOLVED MAGNESIUM	6753.00	UG/L			N/A
MSFC-021R	98Q2	TOTAL DISSOLVED MANGANESE	3762.00	UG/L			N/A
MSFC-026	98Q2	TOTAL DISSOLVED MANGANESE	46.00	UG/L			N/A
MSFC-032	98Q2	TOTAL DISSOLVED MANGANESE	788.00	UG/L			N/A
MSFC-038	98Q2	TOTAL DISSOLVED MANGANESE	29.00	UG/L			N/A
MSFC-039	98Q2	TOTAL DISSOLVED MANGANESE	450.00	UG/L			N/A
MSFC-049	98Q2	TOTAL DISSOLVED MANGANESE	1418.00	UG/L			N/A
MSFC-021R	98Q2	TOTAL DISSOLVED POTASSIUM	2559.00	UG/L			N/A
MSFC-022R	98Q2	TOTAL DISSOLVED POTASSIUM	561.00	UG/L			N/A
MSFC-025	98Q2	TOTAL DISSOLVED POTASSIUM	2728.00	UG/L			N/A
MSFC-026	98Q2	TOTAL DISSOLVED POTASSIUM	1324.00	UG/L			N/A
MSFC-032	98Q2	TOTAL DISSOLVED POTASSIUM	365.00	UG/L			N/A
MSFC-038	98Q2	TOTAL DISSOLVED POTASSIUM	289.00	UG/L			N/A
MSFC-039	98Q2	TOTAL DISSOLVED POTASSIUM	407.00	UG/L			N/A
MSFC-049	98Q2	TOTAL DISSOLVED POTASSIUM	367.00	UG/L			N/A
MSFC-021R	98Q2	TOTAL DISSOLVED SODIUM	36504.00	UG/L			N/A
MSFC-022R	98Q2	TOTAL DISSOLVED SODIUM	3088.00	UG/L			N/A
MSFC-025	98Q2	TOTAL DISSOLVED SODIUM	3695.00	UG/L			N/A
MSFC-026	98Q2	TOTAL DISSOLVED SODIUM	3754.00	UG/L			N/A
MSFC-032	98Q2	TOTAL DISSOLVED SODIUM	6047.00	UG/L			N/A
MSFC-038	98Q2	TOTAL DISSOLVED SODIUM	1244.00	UG/L			N/A
MSFC-039	98Q2	TOTAL DISSOLVED SODIUM	3774.00	UG/L			N/A
MSFC-049	98Q2	TOTAL DISSOLVED SODIUM	8251.00	UG/L			N/A
MSFC-021R	98Q2	TOTAL DISSOLVED SOLIDS	246000.00	UG/L			N/A

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					Background		Human Health		
							MCL or RBC		
MSFC-022R	98Q2	TOTAL DISSOLVED SOLIDS	205000.00	UG/L					N/A
MSFC-025	98Q2	TOTAL DISSOLVED SOLIDS	180000.00	UG/L					N/A
MSFC-026	98Q2	TOTAL DISSOLVED SOLIDS	223000.00	UG/L					N/A
MSFC-029D	98Q2	TOTAL DISSOLVED SOLIDS	185000.00	UG/L					N/A
MSFC-032	98Q2	TOTAL DISSOLVED SOLIDS	157000.00	UG/L					N/A
MSFC-033D	98Q2	TOTAL DISSOLVED SOLIDS	215000.00	UG/L					N/A
MSFC-034D	98Q2	TOTAL DISSOLVED SOLIDS	207000.00	UG/L					N/A
MSFC-038	98Q2	TOTAL DISSOLVED SOLIDS	15000.00	UG/L					N/A
MSFC-039	98Q2	TOTAL DISSOLVED SOLIDS	228000.00	UG/L					N/A
MSFC-047	98Q2	TOTAL DISSOLVED SOLIDS	218000.00	UG/L					N/A
MSFC-049	98Q2	TOTAL DISSOLVED SOLIDS	249000.00	UG/L					N/A
MSFC-051D	98Q2	TOTAL DISSOLVED SOLIDS	249000.00	UG/L					N/A
MSFC-025	98Q2	TOTAL POTASSIUM	2740.00	UG/L	2620.00	X			N/A
MSFC-022R	98Q2	TOTAL ALUMINUM	13.00	UG/L	2970.00		200.00		N
MSFC-025	98Q2	TOTAL ALUMINUM	83.00	UG/L	2970.00		200.00		N
MSFC-032	98Q2	TOTAL ALUMINUM	123.00	UG/L	2970.00		200.00		N
MSFC-033D	98Q2	TOTAL ALUMINUM	85.00	UG/L	2970.00		200.00		N
MSFC-038	98Q2	TOTAL ALUMINUM	397.00	UG/L	2970.00		200.00	X	N
MSFC-021R	98Q2	TOTAL BARIUM	292.00	UG/L	41.30	X	2000.00		N
MSFC-022R	98Q2	TOTAL BARIUM	18.00	UG/L	41.30		2000.00		N
MSFC-025	98Q2	TOTAL BARIUM	30.00	UG/L	41.30		2000.00		N
MSFC-026	98Q2	TOTAL BARIUM	38.00	UG/L	41.30		2000.00		N
MSFC-032	98Q2	TOTAL BARIUM	39.00	UG/L	41.30		2000.00		N
MSFC-033D	98Q2	TOTAL BARIUM	45.00	UG/L	41.30	X	2000.00		N
MSFC-034D	98Q2	TOTAL BARIUM	34.00	UG/L	41.30		2000.00		N
MSFC-039	98Q2	TOTAL BARIUM	32.00	UG/L	41.30		2000.00		N
MSFC-047	98Q2	TOTAL BARIUM	13.00	UG/L	41.30		2000.00		N
MSFC-049	98Q2	TOTAL BARIUM	52.00	UG/L	41.30	X	2000.00		N
MSFC-051D	98Q2	TOTAL BARIUM	21.00	UG/L	41.30		2000.00		N
MSFC-029D	98Q2	TOTAL COPPER	16.00	UG/L			1300.00		N
MSFC-022R	98Q2	TOTAL IRON	44.00	UG/L	4640.00		11000.00		N
MSFC-025	98Q2	TOTAL IRON	67.00	UG/L	4640.00		11000.00		N
MSFC-026	98Q2	TOTAL IRON	45.00	UG/L	4640.00		11000.00		N
MSFC-032	98Q2	TOTAL IRON	2232.00	UG/L	4640.00		11000.00		N
MSFC-033D	98Q2	TOTAL IRON	108.00	UG/L	4640.00		11000.00		N
MSFC-034D	98Q2	TOTAL IRON	52.00	UG/L	4640.00		11000.00		N
MSFC-038	98Q2	TOTAL IRON	325.00	UG/L	4640.00		11000.00		N
MSFC-039	98Q2	TOTAL IRON	1218.00	UG/L	4640.00		11000.00		N
MSFC-047	98Q2	TOTAL IRON	37.00	UG/L	4640.00		11000.00		N
MSFC-049	98Q2	TOTAL IRON	309.00	UG/L	4640.00		11000.00		N
MSFC-051D	98Q2	TOTAL IRON	58.00	UG/L	4640.00		11000.00		N
MSFC-022R	98Q2	TOTAL MAGNESIUM	5127.00	UG/L	7220.00		50.00	X	N
MSFC-025	98Q2	TOTAL MAGNESIUM	5005.00	UG/L	7220.00		50.00	X	N
MSFC-026	98Q2	TOTAL MAGNESIUM	6946.00	UG/L	7220.00		50.00	X	N
MSFC-032	98Q2	TOTAL MAGNESIUM	3407.00	UG/L	7220.00		50.00	X	N

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					Background		Human Health		
							MCL or RBC		
MSFC-038	98Q2	TOTAL MAGNESIUM	622.00	UG/L	7220.00		50.00	X	N
MSFC-047	98Q2	TOTAL MAGNESIUM	6235.00	UG/L	7220.00		50.00	X	N
MSFC-049	98Q2	TOTAL MAGNESIUM	6855.00	UG/L	7220.00		50.00	X	N
MSFC-025	98Q2	TOTAL MANGANESE	11.00	UG/L	216.00		83.95		N
MSFC-026	98Q2	TOTAL MANGANESE	51.00	UG/L	216.00		83.95		N
MSFC-038	98Q2	TOTAL MANGANESE	42.00	UG/L	216.00		83.95		N
MSFC-021R	98Q2	TOTAL POTASSIUM	2593.00	UG/L	2620.00				N
MSFC-022R	98Q2	TOTAL POTASSIUM	556.00	UG/L	2620.00				N
MSFC-026	98Q2	TOTAL POTASSIUM	1374.00	UG/L	2620.00				N
MSFC-032	98Q2	TOTAL POTASSIUM	364.00	UG/L	2620.00				N
MSFC-033D	98Q2	TOTAL POTASSIUM	1667.00	UG/L	2620.00				N
MSFC-034D	98Q2	TOTAL POTASSIUM	409.00	UG/L	2620.00				N
MSFC-038	98Q2	TOTAL POTASSIUM	380.00	UG/L	2620.00				N
MSFC-039	98Q2	TOTAL POTASSIUM	411.00	UG/L	2620.00				N
MSFC-047	98Q2	TOTAL POTASSIUM	608.00	UG/L	2620.00				N
MSFC-049	98Q2	TOTAL POTASSIUM	372.00	UG/L	2620.00				N
MSFC-051D	98Q2	TOTAL POTASSIUM	912.00	UG/L	2620.00				N
MSFC-022R	98Q2	TOTAL SODIUM	3221.00	UG/L	6790.00		20000.00		N
MSFC-025	98Q2	TOTAL SODIUM	3708.00	UG/L	6790.00		20000.00		N
MSFC-026	98Q2	TOTAL SODIUM	3923.00	UG/L	6790.00		20000.00		N
MSFC-032	98Q2	TOTAL SODIUM	6055.00	UG/L	6790.00		20000.00		N
MSFC-034D	98Q2	TOTAL SODIUM	2302.00	UG/L	6790.00		20000.00		N
MSFC-038	98Q2	TOTAL SODIUM	1313.00	UG/L	6790.00		20000.00		N
MSFC-039	98Q2	TOTAL SODIUM	3869.00	UG/L	6790.00		20000.00		N
MSFC-047	98Q2	TOTAL SODIUM	3506.00	UG/L	6790.00		20000.00		N
MSFC-049	98Q2	TOTAL SODIUM	8380.00	UG/L	6790.00	X	20000.00		N
MSFC-038	98Q2	TOTAL ZINC	10.00	UG/L	92.10		5000.00		N

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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-021R	98Q3	TOTAL IRON	32313.00	UG/L	4640.00	X	11000.00	X	Y
MSFC-029D	98Q3	TOTAL MAGNESIUM	21484.00	UG/L	7220.00	X	50.00	X	Y
MSFC-033D	98Q3	TOTAL MAGNESIUM	20201.00	UG/L	7220.00	X	50.00	X	Y
MSFC-034D	98Q3	TOTAL MAGNESIUM	18313.00	UG/L	7220.00	X	50.00	X	Y
MSFC-039	98Q3	TOTAL MAGNESIUM	11333.00	UG/L	7220.00	X	50.00	X	Y
MSFC-051D	98Q3	TOTAL MAGNESIUM	17330.00	UG/L	7220.00	X	50.00	X	Y
MSFC-021R	98Q3	TOTAL MANGANESE	3509.00	UG/L	216.00	X	83.95	X	Y
MSFC-032	98Q3	TOTAL MANGANESE	2147.00	UG/L	216.00	X	83.95	X	Y
MSFC-021R	98Q3	TOTAL SODIUM	60656.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-033D	98Q3	TOTAL SODIUM	25489.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-051D	98Q3	TOTAL SODIUM	25113.00	UG/L	6790.00	X	20000.00	X	Y
MSFC-021R	98Q3	CHLORIDE	4060.00	UG/L					N/A
MSFC-022R	98Q3	CHLORIDE	4520.00	UG/L					N/A
MSFC-025	98Q3	CHLORIDE	6490.00	UG/L					N/A
MSFC-026	98Q3	CHLORIDE	6920.00	UG/L					N/A
MSFC-029D	98Q3	CHLORIDE	980.00	UG/L					N/A
MSFC-032	98Q3	CHLORIDE	5290.00	UG/L					N/A
MSFC-033D	98Q3	CHLORIDE	2290.00	UG/L					N/A
MSFC-034D	98Q3	CHLORIDE	9340.00	UG/L					N/A
MSFC-038	98Q3	CHLORIDE	2200.00	UG/L					N/A
MSFC-039	98Q3	CHLORIDE	5090.00	UG/L					N/A
MSFC-047	98Q3	CHLORIDE	4570.00	UG/L					N/A
MSFC-049	98Q3	CHLORIDE	3810.00	UG/L					N/A
MSFC-051D	98Q3	CHLORIDE	9170.00	UG/L					N/A
MSFC-021R	98Q3	SULFATE	29360.00	UG/L					N/A
MSFC-022R	98Q3	SULFATE	3430.00	UG/L					N/A
MSFC-025	98Q3	SULFATE	24010.00	UG/L					N/A
MSFC-026	98Q3	SULFATE	42850.00	UG/L					N/A
MSFC-029D	98Q3	SULFATE	5230.00	UG/L					N/A
MSFC-032	98Q3	SULFATE	5890.00	UG/L					N/A
MSFC-033D	98Q3	SULFATE	14770.00	UG/L					N/A
MSFC-034D	98Q3	SULFATE	8460.00	UG/L					N/A
MSFC-038	98Q3	SULFATE	200.00	UG/L					N/A
MSFC-039	98Q3	SULFATE	5540.00	UG/L					N/A
MSFC-047	98Q3	SULFATE	3380.00	UG/L					N/A
MSFC-049	98Q3	SULFATE	4050.00	UG/L					N/A
MSFC-051D	98Q3	SULFATE	57620.00	UG/L					N/A
MSFC-022R	98Q3	TOTAL DISSOLVED ALUMINUM	11.00	UG/L					N/A
MSFC-025	98Q3	TOTAL DISSOLVED ALUMINUM	18.00	UG/L					N/A
MSFC-038	98Q3	TOTAL DISSOLVED ALUMINUM	28.00	UG/L					N/A
MSFC-049	98Q3	TOTAL DISSOLVED ALUMINUM	247.00	UG/L					N/A
MSFC-021R	98Q3	TOTAL DISSOLVED BARIUM	548.00	UG/L					N/A
MSFC-022R	98Q3	TOTAL DISSOLVED BARIUM	28.00	UG/L					N/A
MSFC-025	98Q3	TOTAL DISSOLVED BARIUM	55.00	UG/L					N/A
MSFC-026	98Q3	TOTAL DISSOLVED BARIUM	70.00	UG/L					N/A

Appendix A
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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria		Final Exceedance
					Background	Human Health	
						MCL or RBC	Y/N
MSFC-032	98Q3	TOTAL DISSOLVED BARIUM	84.00	UG/L			N/A
MSFC-038	98Q3	TOTAL DISSOLVED BARIUM	13.00	UG/L			N/A
MSFC-039	98Q3	TOTAL DISSOLVED BARIUM	35.00	UG/L			N/A
MSFC-049	98Q3	TOTAL DISSOLVED BARIUM	73.00	UG/L			N/A
MSFC-021R	98Q3	TOTAL DISSOLVED IRON	32898.00	UG/L			N/A
MSFC-022R	98Q3	TOTAL DISSOLVED IRON	147.00	UG/L			N/A
MSFC-025	98Q3	TOTAL DISSOLVED IRON	158.00	UG/L			N/A
MSFC-026	98Q3	TOTAL DISSOLVED IRON	155.00	UG/L			N/A
MSFC-032	98Q3	TOTAL DISSOLVED IRON	7122.00	UG/L			N/A
MSFC-038	98Q3	TOTAL DISSOLVED IRON	108.00	UG/L			N/A
MSFC-039	98Q3	TOTAL DISSOLVED IRON	220.00	UG/L			N/A
MSFC-049	98Q3	TOTAL DISSOLVED IRON	132.00	UG/L			N/A
MSFC-021R	98Q3	TOTAL DISSOLVED MAGNESIUM	6482.00	UG/L			N/A
MSFC-022R	98Q3	TOTAL DISSOLVED MAGNESIUM	5650.00	UG/L			N/A
MSFC-025	98Q3	TOTAL DISSOLVED MAGNESIUM	5842.00	UG/L			N/A
MSFC-026	98Q3	TOTAL DISSOLVED MAGNESIUM	6512.00	UG/L			N/A
MSFC-032	98Q3	TOTAL DISSOLVED MAGNESIUM	3420.00	UG/L			N/A
MSFC-038	98Q3	TOTAL DISSOLVED MAGNESIUM	573.00	UG/L			N/A
MSFC-039	98Q3	TOTAL DISSOLVED MAGNESIUM	11320.00	UG/L			N/A
MSFC-049	98Q3	TOTAL DISSOLVED MAGNESIUM	6871.00	UG/L			N/A
MSFC-021R	98Q3	TOTAL DISSOLVED MANGANESE	3639.00	UG/L			N/A
MSFC-026	98Q3	TOTAL DISSOLVED MANGANESE	19.00	UG/L			N/A
MSFC-032	98Q3	TOTAL DISSOLVED MANGANESE	2177.00	UG/L			N/A
MSFC-038	98Q3	TOTAL DISSOLVED MANGANESE	35.00	UG/L			N/A
MSFC-039	98Q3	TOTAL DISSOLVED MANGANESE	120.00	UG/L			N/A
MSFC-049	98Q3	TOTAL DISSOLVED MANGANESE	61.00	UG/L			N/A
MSFC-021R	98Q3	TOTAL DISSOLVED NICKEL	66.00	UG/L			N/A
MSFC-022R	98Q3	TOTAL DISSOLVED NICKEL	64.00	UG/L			N/A
MSFC-025	98Q3	TOTAL DISSOLVED NICKEL	62.00	UG/L			N/A
MSFC-026	98Q3	TOTAL DISSOLVED NICKEL	65.00	UG/L			N/A
MSFC-032	98Q3	TOTAL DISSOLVED NICKEL	60.00	UG/L			N/A
MSFC-038	98Q3	TOTAL DISSOLVED NICKEL	57.00	UG/L			N/A
MSFC-039	98Q3	TOTAL DISSOLVED NICKEL	58.00	UG/L			N/A
MSFC-049	98Q3	TOTAL DISSOLVED NICKEL	56.00	UG/L			N/A
MSFC-021R	98Q3	TOTAL DISSOLVED POTASSIUM	3515.00	UG/L			N/A
MSFC-022R	98Q3	TOTAL DISSOLVED POTASSIUM	523.00	UG/L			N/A
MSFC-025	98Q3	TOTAL DISSOLVED POTASSIUM	2579.00	UG/L			N/A
MSFC-026	98Q3	TOTAL DISSOLVED POTASSIUM	1356.00	UG/L			N/A
MSFC-032	98Q3	TOTAL DISSOLVED POTASSIUM	388.00	UG/L			N/A
MSFC-038	98Q3	TOTAL DISSOLVED POTASSIUM	231.00	UG/L			N/A
MSFC-039	98Q3	TOTAL DISSOLVED POTASSIUM	380.00	UG/L			N/A
MSFC-049	98Q3	TOTAL DISSOLVED POTASSIUM	380.00	UG/L			N/A
MSFC-021R	98Q3	TOTAL DISSOLVED SODIUM	60754.00	UG/L			N/A
MSFC-022R	98Q3	TOTAL DISSOLVED SODIUM	3035.00	UG/L			N/A
MSFC-025	98Q3	TOTAL DISSOLVED SODIUM	6970.00	UG/L			N/A

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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-026	98Q3	TOTAL DISSOLVED SODIUM	11017.00	UG/L					N/A
MSFC-032	98Q3	TOTAL DISSOLVED SODIUM	6474.00	UG/L					N/A
MSFC-038	98Q3	TOTAL DISSOLVED SODIUM	1122.00	UG/L					N/A
MSFC-039	98Q3	TOTAL DISSOLVED SODIUM	3204.00	UG/L					N/A
MSFC-049	98Q3	TOTAL DISSOLVED SODIUM	4160.00	UG/L					N/A
MSFC-021R	98Q3	TOTAL DISSOLVED SOLIDS	287000.00	UG/L					N/A
MSFC-022R	98Q3	TOTAL DISSOLVED SOLIDS	219000.00	UG/L					N/A
MSFC-025	98Q3	TOTAL DISSOLVED SOLIDS	195000.00	UG/L					N/A
MSFC-026	98Q3	TOTAL DISSOLVED SOLIDS	228000.00	UG/L					N/A
MSFC-029D	98Q3	TOTAL DISSOLVED SOLIDS	187000.00	UG/L					N/A
MSFC-032	98Q3	TOTAL DISSOLVED SOLIDS	171000.00	UG/L					N/A
MSFC-033D	98Q3	TOTAL DISSOLVED SOLIDS	222000.00	UG/L					N/A
MSFC-034D	98Q3	TOTAL DISSOLVED SOLIDS	203000.00	UG/L					N/A
MSFC-038	98Q3	TOTAL DISSOLVED SOLIDS	8000.00	UG/L					N/A
MSFC-039	98Q3	TOTAL DISSOLVED SOLIDS	191000.00	UG/L					N/A
MSFC-047	98Q3	TOTAL DISSOLVED SOLIDS	167000.00	UG/L					N/A
MSFC-049	98Q3	TOTAL DISSOLVED SOLIDS	205000.00	UG/L					N/A
MSFC-051D	98Q3	TOTAL DISSOLVED SOLIDS	220000.00	UG/L					N/A
MSFC-025	98Q3	TOTAL DISSOLVED ZINC	24.00	UG/L					N/A
MSFC-026	98Q3	TOTAL DISSOLVED ZINC	36.00	UG/L					N/A
MSFC-032	98Q3	TOTAL DISSOLVED ZINC	11.00	UG/L					N/A
MSFC-021R	98Q3	TOTAL POTASSIUM	3436.00	UG/L	2620.00	X			N/A
MSFC-025	98Q3	TOTAL POTASSIUM	2677.00	UG/L	2620.00	X			N/A
MSFC-021R	98Q3	TOTAL ALUMINUM	21.00	UG/L	2970.00		200.00		N
MSFC-022R	98Q3	TOTAL ALUMINUM	31.00	UG/L	2970.00		200.00		N
MSFC-025	98Q3	TOTAL ALUMINUM	301.00	UG/L	2970.00		200.00	X	N
MSFC-026	98Q3	TOTAL ALUMINUM	151.00	UG/L	2970.00		200.00		N
MSFC-029D	98Q3	TOTAL ALUMINUM	28.00	UG/L	2970.00		200.00		N
MSFC-032	98Q3	TOTAL ALUMINUM	95.00	UG/L	2970.00		200.00		N
MSFC-033D	98Q3	TOTAL ALUMINUM	116.00	UG/L	2970.00		200.00		N
MSFC-034D	98Q3	TOTAL ALUMINUM	34.00	UG/L	2970.00		200.00		N
MSFC-038	98Q3	TOTAL ALUMINUM	76.00	UG/L	2970.00		200.00		N
MSFC-039	98Q3	TOTAL ALUMINUM	58.00	UG/L	2970.00		200.00		N
MSFC-047	98Q3	TOTAL ALUMINUM	12.00	UG/L	2970.00		200.00		N
MSFC-049	98Q3	TOTAL ALUMINUM	599.00	UG/L	2970.00		200.00	X	N
MSFC-021R	98Q3	TOTAL BARIUM	534.00	UG/L	41.30	X	2000.00		N
MSFC-022R	98Q3	TOTAL BARIUM	28.00	UG/L	41.30		2000.00		N
MSFC-025	98Q3	TOTAL BARIUM	57.00	UG/L	41.30	X	2000.00		N
MSFC-026	98Q3	TOTAL BARIUM	70.00	UG/L	41.30	X	2000.00		N
MSFC-029D	98Q3	TOTAL BARIUM	32.00	UG/L	41.30		2000.00		N
MSFC-032	98Q3	TOTAL BARIUM	85.00	UG/L	41.30	X	2000.00		N
MSFC-033D	98Q3	TOTAL BARIUM	84.00	UG/L	41.30	X	2000.00		N
MSFC-034D	98Q3	TOTAL BARIUM	57.00	UG/L	41.30	X	2000.00		N
MSFC-039	98Q3	TOTAL BARIUM	35.00	UG/L	41.30		2000.00		N
MSFC-047	98Q3	TOTAL BARIUM	21.00	UG/L	41.30		2000.00		N

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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-049	98Q3	TOTAL BARIUM	77.00	UG/L	41.30	X	2000.00		N
MSFC-051D	98Q3	TOTAL BARIUM	32.00	UG/L	41.30		2000.00		N
MSFC-022R	98Q3	TOTAL IRON	86.00	UG/L	4640.00		11000.00		N
MSFC-025	98Q3	TOTAL IRON	266.00	UG/L	4640.00		11000.00		N
MSFC-026	98Q3	TOTAL IRON	274.00	UG/L	4640.00		11000.00		N
MSFC-029D	98Q3	TOTAL IRON	228.00	UG/L	4640.00		11000.00		N
MSFC-032	98Q3	TOTAL IRON	7166.00	UG/L	4640.00	X	11000.00		N
MSFC-033D	98Q3	TOTAL IRON	241.00	UG/L	4640.00		11000.00		N
MSFC-034D	98Q3	TOTAL IRON	155.00	UG/L	4640.00		11000.00		N
MSFC-038	98Q3	TOTAL IRON	123.00	UG/L	4640.00		11000.00		N
MSFC-039	98Q3	TOTAL IRON	266.00	UG/L	4640.00		11000.00		N
MSFC-047	98Q3	TOTAL IRON	130.00	UG/L	4640.00		11000.00		N
MSFC-049	98Q3	TOTAL IRON	730.00	UG/L	4640.00		11000.00		N
MSFC-051D	98Q3	TOTAL IRON	121.00	UG/L	4640.00		11000.00		N
MSFC-021R	98Q3	TOTAL MAGNESIUM	6356.00	UG/L	7220.00		50.00	X	N
MSFC-022R	98Q3	TOTAL MAGNESIUM	5530.00	UG/L	7220.00		50.00	X	N
MSFC-025	98Q3	TOTAL MAGNESIUM	6120.00	UG/L	7220.00		50.00	X	N
MSFC-026	98Q3	TOTAL MAGNESIUM	6624.00	UG/L	7220.00		50.00	X	N
MSFC-032	98Q3	TOTAL MAGNESIUM	3428.00	UG/L	7220.00		50.00	X	N
MSFC-038	98Q3	TOTAL MAGNESIUM	582.00	UG/L	7220.00		50.00	X	N
MSFC-047	98Q3	TOTAL MAGNESIUM	6549.00	UG/L	7220.00		50.00	X	N
MSFC-049	98Q3	TOTAL MAGNESIUM	6662.00	UG/L	7220.00		50.00	X	N
MSFC-026	98Q3	TOTAL MANGANESE	64.00	UG/L	216.00		83.95		N
MSFC-029D	98Q3	TOTAL MANGANESE	34.00	UG/L	216.00		83.95		N
MSFC-033D	98Q3	TOTAL MANGANESE	28.00	UG/L	216.00		83.95		N
MSFC-034D	98Q3	TOTAL MANGANESE	21.00	UG/L	216.00		83.95		N
MSFC-038	98Q3	TOTAL MANGANESE	46.00	UG/L	216.00		83.95		N
MSFC-039	98Q3	TOTAL MANGANESE	144.00	UG/L	216.00		83.95	X	N
MSFC-049	98Q3	TOTAL MANGANESE	118.00	UG/L	216.00		83.95	X	N
MSFC-051D	98Q3	TOTAL MANGANESE	10.00	UG/L	216.00		83.95		N
MSFC-022R	98Q3	TOTAL NICKEL	43.00	UG/L	35.40	X	100.00		N
MSFC-025	98Q3	TOTAL NICKEL	65.00	UG/L	35.40	X	100.00		N
MSFC-026	98Q3	TOTAL NICKEL	68.00	UG/L	35.40	X	100.00		N
MSFC-029D	98Q3	TOTAL NICKEL	67.00	UG/L	35.40	X	100.00		N
MSFC-032	98Q3	TOTAL NICKEL	58.00	UG/L	35.40	X	100.00		N
MSFC-033D	98Q3	TOTAL NICKEL	59.00	UG/L	35.40	X	100.00		N
MSFC-034D	98Q3	TOTAL NICKEL	72.00	UG/L	35.40	X	100.00		N
MSFC-038	98Q3	TOTAL NICKEL	41.00	UG/L	35.40	X	100.00		N
MSFC-039	98Q3	TOTAL NICKEL	61.00	UG/L	35.40	X	100.00		N
MSFC-047	98Q3	TOTAL NICKEL	58.00	UG/L	35.40	X	100.00		N
MSFC-049	98Q3	TOTAL NICKEL	58.00	UG/L	35.40	X	100.00		N
MSFC-051D	98Q3	TOTAL NICKEL	55.00	UG/L	35.40	X	100.00		N
MSFC-022R	98Q3	TOTAL POTASSIUM	616.00	UG/L	2620.00				N
MSFC-026	98Q3	TOTAL POTASSIUM	1375.00	UG/L	2620.00				N
MSFC-029D	98Q3	TOTAL POTASSIUM	1027.00	UG/L	2620.00				N

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Location	Quarter	Parameter	Concentration	Units	Comparison Criteria				Final Exceedance Y/N
					Background		Human Health		
							MCL or RBC		
MSFC-032	98Q3	TOTAL POTASSIUM	400.00	UG/L	2620.00				N
MSFC-033D	98Q3	TOTAL POTASSIUM	1895.00	UG/L	2620.00				N
MSFC-034D	98Q3	TOTAL POTASSIUM	322.00	UG/L	2620.00				N
MSFC-038	98Q3	TOTAL POTASSIUM	240.00	UG/L	2620.00				N
MSFC-039	98Q3	TOTAL POTASSIUM	384.00	UG/L	2620.00				N
MSFC-047	98Q3	TOTAL POTASSIUM	517.00	UG/L	2620.00				N
MSFC-049	98Q3	TOTAL POTASSIUM	406.00	UG/L	2620.00				N
MSFC-051D	98Q3	TOTAL POTASSIUM	718.00	UG/L	2620.00				N
MSFC-022R	98Q3	TOTAL SODIUM	2842.00	UG/L	6790.00		20000.00		N
MSFC-025	98Q3	TOTAL SODIUM	7207.00	UG/L	6790.00	X	20000.00		N
MSFC-026	98Q3	TOTAL SODIUM	10217.00	UG/L	6790.00	X	20000.00		N
MSFC-029D	98Q3	TOTAL SODIUM	4877.00	UG/L	6790.00		20000.00		N
MSFC-032	98Q3	TOTAL SODIUM	6528.00	UG/L	6790.00		20000.00		N
MSFC-034D	98Q3	TOTAL SODIUM	2463.00	UG/L	6790.00		20000.00		N
MSFC-038	98Q3	TOTAL SODIUM	1330.00	UG/L	6790.00		20000.00		N
MSFC-039	98Q3	TOTAL SODIUM	3218.00	UG/L	6790.00		20000.00		N
MSFC-047	98Q3	TOTAL SODIUM	3237.00	UG/L	6790.00		20000.00		N
MSFC-049	98Q3	TOTAL SODIUM	3959.00	UG/L	6790.00		20000.00		N
MSFC-022R	98Q3	TOTAL ZINC	18.00	UG/L	92.10		5000.00		N
MSFC-025	98Q3	TOTAL ZINC	11.00	UG/L	92.10		5000.00		N
MSFC-026	98Q3	TOTAL ZINC	43.00	UG/L	92.10		5000.00		N
MSFC-032	98Q3	TOTAL ZINC	11.00	UG/L	92.10		5000.00		N
MSFC-033D	98Q3	TOTAL ZINC	11.00	UG/L	92.10		5000.00		N
MSFC-049	98Q3	TOTAL ZINC	12.00	UG/L	92.10		5000.00		N

MSFC-044 Residential Risk Assessment Calculations for Subsurface Soil

Appendix A
MSFC-044–Subsurface Soil
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Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-032	13.5	15.5	Arsenic	1.89E+01	=	MG/KG	1.36E+01	X	1.50E+01	X	Y
SB09-039	14	16	Arsenic	1.92E+01	=	MG/KG	1.36E+01	X	1.50E+01	X	Y
SB09-044	15	17	Arsenic	1.52E+01	=	MG/KG	1.36E+01	X	1.50E+01	X	Y
SB09-047	17	18	Arsenic	1.77E+01	=	MG/KG	1.36E+01	X	1.50E+01	X	Y
SB09-049	15	17	Arsenic	1.68E+01	=	MG/KG	1.36E+01	X	1.50E+01	X	Y
SB09-041	14.5	16.5	Lead	2.92E+01	J	MG/KG	2.63E+01	X	1.50E+01	X	Y
SB09-048	15	19	Manganese	5.40E+02	=	MG/KG	4.90E+02	X	5.00E+00	X	Y
SB09-042	14	16	Mercury	5.40E-01	=	MG/KG	1.93E-01	X	2.00E-01	X	Y
SB09-032	13.5	15.5	Nickel	2.66E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-031	14	15	Nickel	3.79E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-036	14	16	Nickel	5.89E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-039	14	16	Nickel	3.81E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-040	16	18	Nickel	4.80E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-043	10.5	12.5	Nickel	5.34E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-044	15	17	Nickel	2.41E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-041	14.5	16.5	Nickel	5.19E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-042	14	16	Nickel	5.56E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-047	17	18	Nickel	7.12E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-045	14	16	Nickel	2.24E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-049	15	17	Nickel	5.86E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-050	14	17	Nickel	6.60E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-032	13.5	15.5	Cadmium	2.50E+00	J	MG/KG	1.57E+00	X			N/A
SB09-038	13	17	Calcium	1.57E+03	=	MG/KG	1.20E+03	X			N/A
SB09-048	15	19	Calcium	2.53E+03	=	MG/KG	1.20E+03	X			N/A
SB09-038	13	17	Magnesium	8.51E+02	=	MG/KG	7.45E+02	X			N/A
SB09-034	14	16	Aluminum	1.65E+04	=	MG/KG	3.33E+04				N
SB09-035	11	13	Aluminum	7.77E+03	=	MG/KG	3.33E+04				N
SB09-032	13.5	15.5	Aluminum	1.82E+04	=	MG/KG	3.33E+04				N
SB09-033	8.5	10.5	Aluminum	2.38E+04	=	MG/KG	3.33E+04				N
SB09-031	14	15	Aluminum	9.45E+03	=	MG/KG	3.33E+04				N
SB09-037	11	13	Aluminum	1.44E+04	=	MG/KG	3.33E+04				N
SB09-038	13	17	Aluminum	1.56E+04	=	MG/KG	3.33E+04				N
SB09-036	14	16	Aluminum	2.00E+04	=	MG/KG	3.33E+04				N
SB09-039	14	16	Aluminum	1.90E+04	=	MG/KG	3.33E+04				N
SB09-040	16	18	Aluminum	1.58E+04	=	MG/KG	3.33E+04				N
SB09-038	13	17	Aluminum	1.06E+04	=	MG/KG	3.33E+04				N
SB09-043	10.5	12.5	Aluminum	2.22E+04	=	MG/KG	3.33E+04				N
SB09-044	15	17	Aluminum	2.21E+04	=	MG/KG	3.33E+04				N
SB09-041	14.5	16.5	Aluminum	3.12E+04	=	MG/KG	3.33E+04				N
SB09-042	14	16	Aluminum	2.32E+04	=	MG/KG	3.33E+04				N
SB09-046	16	18	Aluminum	1.84E+04	=	MG/KG	3.33E+04				N
SB09-047	17	18	Aluminum	2.26E+04	=	MG/KG	3.33E+04				N
SB09-045	14	16	Aluminum	1.55E+04	=	MG/KG	3.33E+04				N
SB09-049	15	17	Aluminum	1.43E+04	=	MG/KG	3.33E+04				N

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-050	14	17	Aluminum	1.36E+04	=	MG/KG	3.33E+04				N
SB09-048	15	19	Aluminum	2.22E+04	=	MG/KG	3.33E+04				N
SB09-040	16	18	Antimony	3.20E+00	J	MG/KG	8.00E+00				N
SB09-046	16	18	Antimony	2.50E+00	J	MG/KG	8.00E+00				N
SB09-034	14	16	Arsenic	8.00E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-035	11	13	Arsenic	1.17E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-033	8.5	10.5	Arsenic	4.80E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-031	14	15	Arsenic	9.60E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-037	11	13	Arsenic	6.50E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-038	13	17	Arsenic	3.10E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-036	14	16	Arsenic	7.40E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-040	16	18	Arsenic	1.43E+01	=	MG/KG	1.36E+01	X	1.50E+01		N
SB09-038	13	17	Arsenic	2.80E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-043	10.5	12.5	Arsenic	1.23E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-041	14.5	16.5	Arsenic	5.20E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-042	14	16	Arsenic	1.32E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-046	16	18	Arsenic	4.80E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-045	14	16	Arsenic	1.07E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-050	14	17	Arsenic	1.07E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-048	15	19	Arsenic	1.04E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-038	13	17	Barium	5.80E+01	=	MG/KG	6.07E+01		3.20E+01	X	N
SB09-038	13	17	Barium	4.02E+01	=	MG/KG	6.07E+01		3.20E+01	X	N
SB09-048	15	19	Barium	3.74E+01	=	MG/KG	6.07E+01		3.20E+01	X	N
SB09-034	14	16	Beryllium	8.30E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-035	11	13	Beryllium	6.80E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-032	13.5	15.5	Beryllium	9.40E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-033	8.5	10.5	Beryllium	8.50E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-031	14	15	Beryllium	1.40E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-037	11	13	Beryllium	5.40E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-038	13	17	Beryllium	5.20E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-036	14	16	Beryllium	2.20E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-039	14	16	Beryllium	1.70E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-040	16	18	Beryllium	3.90E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-038	13	17	Beryllium	2.60E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-043	10.5	12.5	Beryllium	2.20E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-044	15	17	Beryllium	8.10E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-041	14.5	16.5	Beryllium	2.10E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-042	14	16	Beryllium	7.60E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-046	16	18	Beryllium	7.60E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-047	17	18	Beryllium	4.60E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-045	14	16	Beryllium	9.30E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-049	15	17	Beryllium	5.30E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-050	14	17	Beryllium	5.10E+00	J	MG/KG	1.26E+00	X	1.80E+02		N
SB09-048	15	19	Beryllium	1.30E+00	J	MG/KG	1.26E+00	X	1.80E+02		N

Appendix A
MSFC-044–Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-034	14	16	Cadmium	5.10E-01	J	MG/KG	1.57E+00				N
SB09-039	14	16	Cadmium	5.10E-01	J	MG/KG	1.57E+00				N
SB09-040	16	18	Cadmium	1.00E+00	J	MG/KG	1.57E+00				N
SB09-043	10.5	12.5	Cadmium	5.50E-01	J	MG/KG	1.57E+00				N
SB09-041	14.5	16.5	Cadmium	1.10E+00	J	MG/KG	1.57E+00				N
SB09-046	16	18	Cadmium	3.90E-01	J	MG/KG	1.57E+00				N
SB09-047	17	18	Cadmium	1.00E+00	J	MG/KG	1.57E+00				N
SB09-049	15	17	Cadmium	9.50E-01	J	MG/KG	1.57E+00				N
SB09-048	15	19	Cadmium	5.90E-01	J	MG/KG	1.57E+00				N
SB09-038	13	17	Calcium	8.59E+02	=	MG/KG	1.20E+03				N
SB09-034	14	16	Chromium	4.67E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-035	11	13	Chromium	9.61E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-032	13.5	15.5	Chromium	3.63E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-033	8.5	10.5	Chromium	2.84E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-031	14	15	Chromium	3.89E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-037	11	13	Chromium	3.59E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-038	13	17	Chromium	4.38E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-036	14	16	Chromium	5.89E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-039	14	16	Chromium	7.47E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-040	16	18	Chromium	9.29E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-038	13	17	Chromium	4.34E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-043	10.5	12.5	Chromium	1.05E+02	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-044	15	17	Chromium	1.02E+02	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-041	14.5	16.5	Chromium	8.46E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-042	14	16	Chromium	8.57E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-046	16	18	Chromium	7.22E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-047	17	18	Chromium	1.09E+02	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-045	14	16	Chromium	1.01E+02	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-049	15	17	Chromium	7.25E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-050	14	17	Chromium	7.10E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-048	15	19	Chromium	8.61E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-038	13	17	Cobalt	5.90E+00	J	MG/KG	9.06E+00		2.19E+02		N
SB09-038	13	17	Cobalt	5.00E+00	J	MG/KG	9.06E+00		2.19E+02		N
SB09-048	15	19	Cobalt	9.40E+00	=	MG/KG	9.06E+00	X	2.19E+02		N
SB09-033	8.5	10.5	Copper	9.40E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-036	14	16	Copper	1.18E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-039	14	16	Copper	1.77E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-040	16	18	Copper	1.73E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-043	10.5	12.5	Copper	1.33E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-044	15	17	Copper	1.03E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-041	14.5	16.5	Copper	2.41E+01	=	MG/KG	1.93E+01	X	4.50E+01		N
SB09-042	14	16	Copper	1.26E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-047	17	18	Copper	2.06E+01	=	MG/KG	1.93E+01	X	4.50E+01		N
SB09-049	15	17	Copper	1.17E+01	=	MG/KG	1.93E+01		4.50E+01		N

Appendix A
MSFC-044–Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-050	14	17	Copper	1.24E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-048	15	19	Copper	1.11E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-034	14	16	Iron	2.20E+04	=	MG/KG	6.86E+04				N
SB09-035	11	13	Iron	2.81E+04	=	MG/KG	6.86E+04				N
SB09-032	13.5	15.5	Iron	1.78E+04	=	MG/KG	6.86E+04				N
SB09-033	8.5	10.5	Iron	1.87E+04	=	MG/KG	6.86E+04				N
SB09-031	14	15	Iron	9.79E+03	=	MG/KG	6.86E+04				N
SB09-037	11	13	Iron	2.18E+01	=	MG/KG	6.86E+04				N
SB09-038	13	17	Iron	1.94E+04	=	MG/KG	6.86E+04				N
SB09-036	14	16	Iron	6.11E+04	=	MG/KG	6.86E+04				N
SB09-039	14	16	Iron	4.93E+04	=	MG/KG	6.86E+04				N
SB09-040	16	18	Iron	4.82E+04	=	MG/KG	6.86E+04				N
SB09-038	13	17	Iron	1.35E+04	=	MG/KG	6.86E+04				N
SB09-043	10.5	12.5	Iron	3.63E+04	=	MG/KG	6.86E+04				N
SB09-044	15	17	Iron	3.70E+04	=	MG/KG	6.86E+04				N
SB09-041	14.5	16.5	Iron	2.65E+04	=	MG/KG	6.86E+04				N
SB09-042	14	16	Iron	4.18E+04	=	MG/KG	6.86E+04				N
SB09-046	16	18	Iron	3.05E+04	=	MG/KG	6.86E+04				N
SB09-047	17	18	Iron	4.37E+04	=	MG/KG	6.86E+04				N
SB09-045	14	16	Iron	3.75E+04	=	MG/KG	6.86E+04				N
SB09-049	15	17	Iron	2.88E+04	=	MG/KG	6.86E+04				N
SB09-050	14	17	Iron	2.98E+04	=	MG/KG	6.86E+04				N
SB09-048	15	19	Iron	3.35E+04	=	MG/KG	6.86E+04				N
SB09-034	14	16	Lead	1.36E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-035	11	13	Lead	2.48E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-032	13.5	15.5	Lead	2.00E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-033	8.5	10.5	Lead	1.86E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-031	14	15	Lead	1.37E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-037	11	13	Lead	2.06E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-038	13	17	Lead	1.15E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-036	14	16	Lead	1.09E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-039	14	16	Lead	1.70E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-040	16	18	Lead	1.15E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-038	13	17	Lead	8.10E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-043	10.5	12.5	Lead	9.60E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-044	15	17	Lead	1.18E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-042	14	16	Lead	1.04E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-046	16	18	Lead	1.98E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-047	17	18	Lead	1.72E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-045	14	16	Lead	8.20E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-049	15	17	Lead	1.06E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-050	14	17	Lead	1.02E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-048	15	19	Lead	8.30E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-038	13	17	Magnesium	4.17E+02	J	MG/KG	7.45E+02				N

Appendix A
MSFC-044–Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-048	15	19	Magnesium	7.39E+02	=	MG/KG	7.45E+02				N
SB09-038	13	17	Manganese	4.43E+02	=	MG/KG	4.90E+02		5.00E+00	X	N
SB09-038	13	17	Manganese	4.19E+02	=	MG/KG	4.90E+02		5.00E+00	X	N
SB09-034	14	16	Mercury	1.00E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-032	13.5	15.5	Mercury	1.30E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-037	11	13	Mercury	1.80E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-044	15	17	Mercury	1.60E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-046	16	18	Mercury	5.00E-02	=	MG/KG	1.93E-01		2.00E-01		N
SB09-047	17	18	Mercury	1.30E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-049	15	17	Mercury	1.10E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-034	14	16	Nickel	1.65E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-035	11	13	Nickel	1.13E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-033	8.5	10.5	Nickel	1.53E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-037	11	13	Nickel	9.10E+00	=	MG/KG	1.78E+01		2.10E+01		N
SB09-038	13	17	Nickel	9.50E+00	=	MG/KG	1.78E+01		2.10E+01		N
SB09-038	13	17	Nickel	7.60E+00	=	MG/KG	1.78E+01		2.10E+01		N
SB09-046	16	18	Nickel	1.64E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-048	15	19	Nickel	1.76E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-038	13	17	Potassium	5.05E+02	J	MG/KG	9.00E+02				N
SB09-038	13	17	Potassium	2.52E+02	J	MG/KG	9.00E+02				N
SB09-048	15	19	Potassium	7.48E+02	=	MG/KG	9.00E+02				N
SB09-038	13	17	Sodium	6.53E+01	J	MG/KG			2.00E+03		N
SB09-038	13	17	Sodium	5.97E+01	J	MG/KG			2.00E+03		N
SB09-048	15	19	Sodium	1.13E+02	J	MG/KG			2.00E+03		N
SB09-035	11	13	Thallium	4.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-032	13.5	15.5	Thallium	4.60E-01	J	MG/KG	6.30E-01		4.00E-01	X	N
SB09-033	8.5	10.5	Thallium	1.40E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-031	14	15	Thallium	2.20E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-037	11	13	Thallium	1.80E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-038	13	17	Thallium	5.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-039	14	16	Thallium	1.00E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-040	16	18	Thallium	8.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-041	14.5	16.5	Thallium	2.50E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-046	16	18	Thallium	7.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-047	17	18	Thallium	9.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-049	15	17	Thallium	1.20E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-050	14	17	Thallium	1.30E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-038	13	17	Vanadium	3.92E+01	=	MG/KG	1.72E+02				N
SB09-038	13	17	Vanadium	3.77E+01	=	MG/KG	1.72E+02				N
SB09-048	15	19	Vanadium	6.97E+01	=	MG/KG	1.72E+02				N
SB09-034	14	16	Zinc	6.78E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-032	13.5	15.5	Zinc	1.12E+02	J	MG/KG	1.17E+02		4.20E+04		N
SB09-033	8.5	10.5	Zinc	5.62E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-031	14	15	Zinc	1.10E+02	J	MG/KG	1.17E+02		4.20E+04		N

Appendix A
MSFC-044–Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-038	13	17	Zinc	5.49E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-036	14	16	Zinc	1.84E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-039	14	16	Zinc	1.67E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-040	16	18	Zinc	1.75E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-043	10.5	12.5	Zinc	1.97E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-044	15	17	Zinc	1.06E+02	J	MG/KG	1.17E+02		4.20E+04		N
SB09-041	14.5	16.5	Zinc	1.58E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-042	14	16	Zinc	1.09E+02	J	MG/KG	1.17E+02		4.20E+04		N
SB09-046	16	18	Zinc	6.60E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-047	17	18	Zinc	3.15E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-045	14	16	Zinc	1.00E+02	J	MG/KG	1.17E+02		4.20E+04		N
SB09-049	15	17	Zinc	2.56E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-050	14	17	Zinc	2.55E+02	J	MG/KG	1.17E+02	X	4.20E+04		N
SB09-048	15	19	Zinc	9.64E+01	J	MG/KG	1.17E+02		4.20E+04		N

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IRadj * FI * ET * EF * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
IR =	Ingestion Rate (mg/day)	N/A	100 a
IR_{adj} =	Age-Specific Ingestion Rate (mg - year)/(kg - day)	114.29 c	N/A
FI =	Fraction Ingested (unitless)	100%	100%
ET =	Exposure Time (hours/day)	1.000 b	1.000 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * SAadj * AF * ABS * ET * EF * CF}{AT}$$

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
SA =	Surface Area (cm^2)	N/A	2936 d
SA_{adj} =	Age-Specific Surface Area (cm^2)	1574 e	N/A
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1 f	1 f
ABS =	Absorption Factor (unitless)	(Chemical Specific) g	(Chemical Specific) g
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * IRinh\_adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09 h	1.32E+09 h
IR_Inh =	Inhalation Rate (m^3/day)	N/A	20 a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86 i	N/A
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.

b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc * EDc}{BWc} + \frac{IRa * (EDa - EDc)}{BWa} = \frac{200 * 6}{15} + \frac{100 * (30-6)}{70}$$

$$= 114.29 \text{ (mg-year)/(kg-day)}$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc * EDc}{BWc} + \frac{SAa * (EDa - EDc)}{BWa} = \frac{1418 * 6}{15} + \frac{2936 * (30-6)}{70}$$

$$= 1574 \text{ } (cm^3\text{-year})/(kg)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc * EDc}{BWc} + \frac{IR\_Inha * (EDa - EDc)}{BWa} = \frac{15 * 6}{15} + \frac{20 * (30-6)}{70}$$

$$= 12.86 \text{ } (m^3\text{-year})/(kg\text{-day})$$

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-044 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**SFd**	**SFi**	**RME**	**DE**	**ABS**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MG/KG	Arsenic	A	1.50E+00	3.66E+00	1.51E+01	1.29E+01	4.10E-01	0.001	2.02E+05	3E+05	4.66E-08	2E-07	2.88E-10	4E-09
MG/KG	Cadmium	B1			6.30E+00	8.46E-01	1.00E-02	0.001	1.32E-06		3.05E-09		1.88E-11	1E-10
MG/KG	Lead	B2				1.75E+01	1.50E-01	0.001	2.73E-05		6.29E-08		3.98E-10	
MG/KG	Manganese	D				5.40E+02	4.00E-02	0.001	8.45E-04		1.94E-06		1.20E-08	
MG/KG	Mercury	D				1.39E-01	1.00E-04	0.001	2.17E-07		4.99E-10		3.09E-12	
MG/KG	Nickel					4.86E+01	2.70E-01	0.001	7.61E-05		1.75E-07		1.08E-09	
	Total Risk									**3E-05**		**2E-07**		**4E-09**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk

Total Risk = 3E-05

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Non-carcinogenic Scenario
MSFC-044 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Arsenic	A	3.00E-04	1.23E-04		1.29E+01	4.10E-01	0.001	1.77E-05	6E-02	8.68E-08	7E-04	4.48E-10	
MG/KG	Cadmium	B1	1.00E-03	1.00E-05		8.46E-01	1.00E-02	0.001	1.16E-06	1E-03	5.68E-08	6E-04	2.93E-11	
MG/KG	Lead	B2				1.75E+01	1.50E-01	0.001	2.39E-05		1.17E-07		6.05E-10	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-05	5.40E+02	4.00E-02	0.001	7.40E-04	5E-03	3.63E-06	6E-04	1.87E-08	1E-03
MG/KG	Mercury	D	3.00E-04	3.00E-03	8.57E-05	1.39E-01	1.00E-04	0.001	1.90E-07	6E-04	9.31E-10	3E-02	4.81E-12	6E-08
MG/KG	Nickel		2.00E-02	5.40E-03		4.86E+01	2.70E-01	0.001	6.66E-05	3E-03	3.26E-07	6E-05	1.68E-09	
	Hazard Index									**7E-02**		**3E-02**		**1E-03**
													Total HI=	**1E-01**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure Time (hours/day)	1.000	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal:

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical Specific)	f
ET =	Exposure Time (hours/day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.
b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.
c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.
d = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.
e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.
f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

Subsurface Soil - Hypothetical Future On-Site Residential (Child) Non-carcinogenic Scenario
MSFC-044 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Arsenic	A	3.00E-04	1.23E-04		1.29E+04	4.10E-01	0.001	1.65E-04	6.E-01	1.96E-07	2.E-03	1.57E-09	
MG/KG	Cadmium	B1	1.00E-03	1.00E-05		8.46E-01	1.00E-02	0.001	1.08E-05	1.E-02	1.28E-08	1.E-03	1.03E-10	
MG/KG	Lead	B2				1.75E+01	1.50E-01	0.001	2.23E-04		2.64E-07		2.12E-09	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-05	5.40E+02	4.00E-02	0.001	6.90E-03	5.E-02	8.17E-06	1.E-03	6.55E-08	5.E-03
MG/KG	Mercury	D	3.00E-04	3.00E-08	8.57E-05	1.39E-01	1.00E-04	0.001	1.77E-06	6.E-03	2.10E-09	7.E-02	1.68E-11	2.E-07
MG/KG	Nickel		2.00E-02	5.40E-03		4.86E+01	2.70E-01	0.001	6.21E-04	3.E-02	7.36E-07	1.E-04	5.90E-09	
	Hazard Index									**6E-01**		**7E-02**		**5E-03**
													Total HI=	**7E-01**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IRadj * FI * ET * EF * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
IR =	Ingestion Rate (mg/day)	N/A	100 a
IR_{adj} =	Age-Specific Ingestion Rate (mg - year)/(kg - day)	114.29 c	N/A
FI =	Fraction Ingested (unitless)	100%	100%
ET =	Exposure Time (hours/day)	1.000 b	1.000 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * SAadj * AF * ABS * ET * EF * CF}{AT}$$

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	RME
SA =	Surface Area (cm^2)	N/A	2936 d
SA_{adj} =	Age-Specific Surface Area (cm^2)	1574 e	N/A
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1 f	1 f
ABS =	Absorption Factor (unitless)	(Chemical Specific) g	(Chemical Specific) g
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * IRinh\_adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	RME
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09 h	1.32E+09 h
IR_Inh =	Inhalation Rate (m^3/day)	N/A	20 a
IR_inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86 i	N/A
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.

b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} + \frac{100 \times (30-6)}{70}$$

$$= 114.29 \text{ (mg-year)/(kg-day)}$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 1574 \text{ } (cm^3\text{-year})/(kg)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc \times EDc}{BWc} + \frac{IR\_Inha \times (EDa - EDc)}{BWa} = \frac{15 \times 6}{15} + \frac{20 \times (30-6)}{70}$$

$$= 12.86 \text{ } (m^3\text{-year})/(kg\text{-day})$$

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-049/050 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**SFd**	**SFi**	**RME**	**DE**	**ABS**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MG/KG	Barium					1.64E+02	7.00E-02	0.001	2.57E-04		5.91E-07		3.66E-09	
MG/KG	Lead	B2				2.25E+01	1.50E-01	0.001	3.53E-05		8.11E-08		5.02E-10	
MG/KG	Manganese	D				1.87E+03	4.00E-02	0.001	2.93E-03		6.73E-06		4.17E-08	
MG/KG	Nickel					1.85E+01	2.70E-01	0.001	2.89E-05		6.65E-08		4.12E-10	
	Total Risk													

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk

Total Risk =

MSFC-A Residential Risk Assessment Calculations for Surface Soil

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IRadj * FI * ET * EF * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
IR =	Ingestion Rate (mg/day)	N/A	100 a
IR_{adj} =	Age-Specific Ingestion Rate (mg - year)/(kg - day)	114.29 c	N/A
FI =	Fraction Ingested (unitless)	100%	100%
ET =	Exposure Time (hours/day)	1.000 b	1.000 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * SAadj * AF * ABS * ET * EF * CF}{AT}$$

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
SA =	Surface Area (cm^2)	N/A	2936 d
SA_{adj} =	Age-Specific Surface Area (cm^2)	1574 e	N/A
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1 f	1 f
ABS =	Absorption Factor (unitless)	(Chemical Specific) g	(Chemical Specific) g
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * IRinh\_adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09 h	1.32E+09 h
IR_Inh =	Inhalation Rate (m^3/day)	N/A	20 a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86 i	N/A
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.

b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} + \frac{100 \times (30-6)}{70}$$

$$= 114.29 \text{ (mg-year)/(kg-day)}$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 1574 \text{ } (cm^3\text{-year})/(kg)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc \times EDc}{BWc} + \frac{IR\_Inha \times (EDa - EDc)}{BWa} = \frac{15 \times 6}{15} + \frac{20 \times (30-6)}{70}$$

$$= 12.86 \text{ } (m^3\text{-year})/(kg\text{-day})$$

Surface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-A OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**SFd**	**SFi**	**RME**	**DE**	**ABS**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MG/KG	Mercury	D				2.20E-01	1.00E-04	0.001	3.44E-07		7.92E-10		4.90E-12	
	Total Risk													

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk

Total Risk =

Surface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-A OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Mercury	D	3.00E-04	3.00E-08	8.57E-05	2.20E-01	1.00E-04	0.001	3.01E-07	1E-03	1.48E-09	5E-02	7.63E-12	9E-08
	Hazard Index									**1E-03**		**5E-02**		**9E-08**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Total Risk = 5E-02

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure Time (hours/day)	1.000	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal:

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical Specific)	f
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emisssion Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.
b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.
c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.
d = Particulate emission factor (PEF), adapted from U.S. EPA, Soil Screening Guidance: Technical Background Document, May 1996.
e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.
f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

Surface Soil - Hypothetical Future On-Site Residential (Child) Non-carcinogenic Scenario
MSFC-A OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Mercury	D	3.00E-04	3.00E-08	8.57E-05	2.20E-01	1.00E-04	0.001	2.81E-06	9E-03	3.33E-09	1E-01	2.67E-11	3E-07
	Hazard Index									**9E-03**		**1E-01**		**3E-07**
Notes:	WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index									**Total Risk =**				**1E-01**

Station ID	Parameter	Conc	Q	Units	Comparison Criteria						Final Exceedance Y/N
					Background		Human Health				
							RBC		GWP		
SB09-005	Mercury	2.20E-01	=	MG/KG	1.56E-01	X	5.21E+01		2.00E-01	X	Y
SB09-003	Acetone	6.70E+00	=	MG/KG			4.07E+02		8.00E+00		N
SB09-003	Aluminum	2.04E+04	=	MG/KG	3.07E+04						N
SB09-002	Antimony	2.70E+00	J	MG/KG	4.72E+00		6.98E+00				N
SB09-003	Arsenic	6.20E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-004	Arsenic	7.20E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-001	Arsenic	4.90E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-005	Arsenic	5.40E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-002	Arsenic	6.80E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-003	Barium	7.00E+01	=	MG/KG	2.11E+02				3.20E+01	X	N
SB09-003	Beryllium	3.80E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+01		N
SB09-004	Beryllium	7.40E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+01		N
SB09-001	Beryllium	3.70E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+01		N
SB09-002	Beryllium	3.10E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+01		N
SB09-003	Chromium	4.56E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-004	Chromium	4.06E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-001	Chromium	2.79E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-005	Chromium	3.16E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-002	Chromium	5.19E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-003	Cobalt	7.30E+00	J	MG/KG	1.91E+01		1.05E+03		2.19E+02		N
SB09-003	Copper	1.00E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-004	Copper	1.04E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-001	Copper	8.10E+00	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-005	Copper	8.20E+00	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-002	Copper	7.90E+00	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-004	Cyanide	6.50E-01	J	MG/KG	3.10E-01	X	3.47E+03		4.00E+01		N
SB09-003	Di-n-butylphthalate	6.00E-02	J	MG/KG			4.07E+02		1.20E+02		N
SB09-003	Iron	3.64E+04	=	MG/KG	3.93E+04						N
SB09-003	Lead	2.70E+00	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-004	Lead	2.80E+00	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-001	Lead	3.50E+00	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-005	Lead	1.78E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-002	Lead	2.04E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-003	Magnesium	4.93E+02	J	MG/KG	9.96E+02						N
SB09-003	Manganese	7.84E+02	=	MG/KG	2.30E+03		1.49E+02	X	5.00E+00	X	N
SB09-003	Mercury	1.50E-01	=	MG/KG	1.56E-01		5.21E+01		2.00E-01		N
SB09-003	Methylene chloride	8.00E-03	J	MG/KG			4.42E+00		1.00E-02		N
SB09-003	Nickel	8.60E+00	J	MG/KG	1.72E+01		3.47E+02		2.10E+01		N
SB09-004	Nickel	1.23E+01	=	MG/KG	1.72E+01		3.47E+02		2.10E+01		N
SB09-001	Nickel	9.40E+00	=	MG/KG	1.72E+01		3.47E+02		2.10E+01		N
SB09-005	Nickel	8.00E+00	J	MG/KG	1.72E+01		3.47E+02		2.10E+01		N
SB09-002	Nickel	1.22E+01	=	MG/KG	1.72E+01		3.47E+02		2.10E+01		N
SB09-003	Potassium	5.31E+02	J	MG/KG	1.21E+03						N
SB09-005	Selenium	3.20E-01	J	MG/KG			8.72E+01		3.00E+00		N
SB09-004	Thallium	4.90E-01	J	MG/KG	7.86E-01		1.40E+00		4.00E-01		N

Appendix A
MSFC-A–Surface Soil
OU-9 Record of Decision

Station ID	Parameter	Conc	Q	Units	Comparison Criteria						Final Exceedance Y/N
					Background		Human Health				
							RBC		GWP		
SB09-001	Thallium	2.10E-01	J	MG/KG	7.86E-01		1.40E+00		4.00E-01		N
SB09-002	Thallium	4.30E-01	J	MG/KG	7.86E-01		1.40E+00		4.00E-01	X	N
SB09-003	Vanadium	8.35E+01	=	MG/KG	8.85E+01		1.22E+02				N
SB09-003	Zinc	4.05E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-004	Zinc	5.85E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-001	Zinc	4.83E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-005	Zinc	5.90E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-002	Zinc	4.39E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N

MSFC-A Residential Risk Assessment
Calculations for Subsurface Soil

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IRadj * FI * ET * EF * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
IR =	Ingestion Rate (mg/day)	N/A	100 a
IR_{adj} =	Age-Specific Ingestion Rate (mg - year)/(kg - day)	114.29 c	N/A
FI =	Fraction Ingested (unitless)	100%	100%
ET =	Exposure Time (hours/day)	1.000 b	1.000 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * SAadj * AF * ABS * ET * EF * CF}{AT}$$

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
SA =	Surface Area (cm^2)	N/A	2936 d
SA_{adj} =	Age-Specific Surface Area (cm^2)	1574 e	N/A
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1 f	1 f
ABS =	Absorption Factor (unitless)	(Chemical Specific) g	(Chemical Specific) g
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * IRinh\_adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09 h	1.32E+09 h
IR_Inh =	Inhalation Rate (m^3/day)	N/A	20 a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86 i	N/A
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.

b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} + \frac{100 \times (30-6)}{70}$$

$$= 114.29 \text{ (mg-year)/(kg-day)}$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 1574 \text{ } (cm^3\text{-year})/(kg)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc \times EDc}{BWc} + \frac{IR\_Inha \times (EDa - EDc)}{BWa} = \frac{15 \times 6}{15} + \frac{20 \times (30-6)}{70}$$

$$= 12.86 \text{ } (m^3\text{-year})/(kg\text{-day})$$

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Non-carcinogenic Scenario
MSFC-A OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.29E+02	7.00E-02	0.001	1.77E-04	3E-03	8.66E-07	2E-04	4.47E-09	3E-05
MG/KG	Cadmium	B1	1.00E-03	1.00E-05		4.40E+00	1.00E-02	0.001	6.03E-06	6E-03	2.96E-08	3E-03	1.53E-10	
MG/KG	Chromium	A	1.00E+00	2.00E-02		1.86E+02	2.00E-02	0.001	2.55E-04	3E-04	1.25E-06	6E-05	6.45E-09	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-05	2.13E+03	4.00E-02	0.001	2.92E-03	2E-02	1.43E-05	3E-03	7.38E-08	5E-03
MG/KG	Nickel		2.00E-02	5.40E-03		4.93E+01	2.70E-01	0.001	6.75E-05	3E-03	3.31E-07	6E-05	1.71E-09	
MG/KG	Arochlor-1254	B2	2.00E-05	1.80E-05		2.00E-02	9.00E-01	0.06	2.74E-08	1E-03	8.06E-09	4E-04	6.93E-13	
MG/KG	2-Butanone	D	6.00E-01	4.80E-01	2.86E-01	1.40E-02	8.00E-01	0.01	1.92E-08	3E-08	9.40E-10	2E-09	4.85E-13	2E-12
MG/KG	Acetone	D	1.00E-01	8.30E-02		1.10E+01	8.30E-01	0.01	1.51E-05	2E-04	7.39E-07	9E-06	3.81E-10	
	Hazard Index									**3E-02**		**6E-03**		**5E-03**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Total HI= 5E-02

Subsurface Soil - Hypothetical Future On-Site Residential (Child) Non-carcinogenic Scenario
MSFC-A OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.29E+02	7.00E-02	0.001	1.65E-03	2.36E-02	1.17E-05	2.39E-03	9.37E-08	6.56E-04
MG/KG	Cadmium	B1	1.00E-03	1.00E-05		4.40E+00	1.00E-02	0.001	5.63E-05	5.63E-02	3.99E-07	3.99E-02	3.20E-09	
MG/KG	Chromium	A	1.00E+00	2.00E-02		1.86E+02	2.00E-02	0.001	2.38E-03	2.38E-03	1.69E-05	8.43E-04	1.35E-07	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-05	2.13E+03	4.00E-02	0.001	2.72E-02	1.95E-01	1.93E-04	3.45E-02	1.55E-05	1.08E-01
MG/KG	Nickel		2.00E-02	5.40E-03		4.93E+01	2.70E-01	0.001	6.30E-04	3.15E-02	4.47E-06	8.28E-04	3.58E-08	
MG/KG	Arochlor-1254	B2	2.00E-05	1.80E-05		2.00E-02	9.00E-01	0.06	2.56E-07	1.28E-02	1.09E-07	6.04E-03	1.45E-11	
MG/KG	2-Butanone	D	6.00E-01	4.80E-01	2.86E-01	1.40E-02	8.00E-01	0.01	1.79E-07	2.98E-07	1.27E-08	2.64E-08	1.02E-11	3.56E-11
MG/KG	Acetone	D	1.00E-01	8.30E-02		1.10E+01	8.30E-01	0.01	1.41E-04	1.41E-03	9.97E-06	1.20E-04	7.99E-09	
	Hazard Index									**3.22E-01**		**8.46E-02**		**1.09E-01**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Total HI= 5.16E-01

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-003	6	7	Acetone	1.10E+01	=	MG/KG			8.00E+00	X	Y
SB09-003	6	7	Barium	1.29E+02	=	MG/KG	6.07E+01	X	3.20E+01	X	Y
SB09-005	6	6.8	Chromium	1.86E+02	=	MG/KG	1.54E+02	X	1.00E+01	X	Y
SB09-003	6	7	Manganese	2.13E+03	=	MG/KG	4.90E+02	X	5.00E+00	X	Y
SB09-005	6	6.8	Nickel	4.93E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-003	6	7	2-Butanone	1.40E-02	J	MG/KG					N/A
SB09-003	6	7	Aroclor-1254	2.00E-02	J	MG/KG					N/A
SB09-005	6	6.8	Cadmium	4.40E+00	=	MG/KG	1.57E+00	X			N/A
SB09-003	6	7	Aluminum	2.46E+04	=	MG/KG	3.33E+04				N
SB09-002	6.5	7	Antimony	3.00E+00	J	MG/KG	8.00E+00				N
SB09-003	6	7	Arsenic	7.60E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-001	6.5	7	Arsenic	1.08E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-005	6	6.8	Arsenic	6.00E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-004	6	7	Arsenic	6.90E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-004	6	7	Arsenic	7.50E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-002	6.5	7	Arsenic	7.00E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-003	6	7	Beryllium	6.60E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-001	6.5	7	Beryllium	1.10E+00	J	MG/KG	1.26E+00		1.80E+02		N
SB09-004	6	7	Beryllium	9.30E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-004	6	7	Beryllium	9.30E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-002	6.5	7	Beryllium	3.30E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-003	6	7	Chromium	4.72E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-001	6.5	7	Chromium	9.02E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-004	6	7	Chromium	3.43E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-004	6	7	Chromium	3.00E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-002	6.5	7	Chromium	3.60E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-005	6	6.8	Chromium, hexavo	1.40E-01	=	MG/KG			3.29E+01	X	N
SB09-003	6	7	Cobalt	2.10E+01	=	MG/KG	9.06E+00	X	2.19E+02		N
SB09-003	6	7	Copper	1.38E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-001	6.5	7	Copper	2.03E+01	=	MG/KG	1.93E+01	X	4.50E+01		N
SB09-005	6	6.8	Copper	1.43E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-004	6	7	Copper	1.48E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-004	6	7	Copper	1.16E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-002	6.5	7	Copper	8.60E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-003	6	7	Cyanide	2.10E-01	J	MG/KG			4.00E+01		N
SB09-003	6	7	Di-n-butylphthalate	5.60E-02	J	MG/KG			1.20E+02		N
SB09-003	6	7	Iron	3.49E+04	=	MG/KG	6.86E+04				N
SB09-003	6	7	Lead	1.63E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-001	6.5	7	Lead	4.70E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-005	6	6.8	Lead	1.31E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-004	6	7	Lead	1.02E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-004	6	7	Lead	1.40E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-002	6.5	7	Lead	1.71E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-003	6	7	Magnesium	6.72E+02	J	MG/KG	7.45E+02				N

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-005	6	6.8	Mercury	1.20E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-003	6	7	Nickel	1.36E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-001	6.5	7	Nickel	1.86E+01	=	MG/KG	1.78E+01	X	2.10E+01		N
SB09-004	6	7	Nickel	1.48E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-004	6	7	Nickel	1.19E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-002	6.5	7	Nickel	7.40E+00	J	MG/KG	1.78E+01		2.10E+01		N
SB09-003	6	7	Potassium	7.95E+02	J	MG/KG	9.00E+02				N
SB09-001	6.5	7	Silver	3.10E+00	=	MG/KG	1.17E+00	X	1.83E+01		N
SB09-005	6	6.8	Silver	6.10E-01	J	MG/KG	1.17E+00		1.83E+01		N
SB09-001	6.5	7	Thallium	5.90E+01	J	MG/KG	6.30E-01		4.00E-01	X	N
SB09-004	6	7	Thallium	4.90E+01	J	MG/KG	6.30E-01		4.00E-01	X	N
SB09-004	6	7	Thallium	6.30E-01	J	MG/KG	6.30E-01		4.00E-01	X	N
SB09-002	6.5	7	Thallium	3.80E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-003	6	7	Vanadium	7.68E+01	=	MG/KG	1.72E+02				N
SB09-003	6	7	Zinc	6.63E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-001	6.5	7	Zinc	9.82E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-005	6	6.8	Zinc	9.16E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-004	6	7	Zinc	6.42E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-004	6	7	Zinc	4.84E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-002	6.5	7	Zinc	3.74E+01	J	MG/KG	1.17E+02		4.20E+04		N

MSFC-045/046 Residential Risk RISK Assessment Calculations for Subsurface Soil

Surface Soil - Hypothetical Future On-Site Residential (Adult) Scenario

MSFC-045/046 OU-9 Record of Decision

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IRadj * FI * ET * EF * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
IR =	Ingestion Rate (mg/day)	N/A	100 a
IR_{adj} =	Age-Specific Ingestion Rate (mg - year)/(kg - day)	114.29 c	N/A
FI =	Fraction Ingested (unitless)	100%	100%
ET =	Exposure Time (hours/day)	1.000 b	1.000 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * SAadj * AF * ABS * ET * EF * CF}{AT}$$

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
SA =	Surface Area (cm^2)	N/A	2936 d
SA_{adj}=	Age-Specific Surface Area (cm^2)	1574 e	N/A
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1 f	1 f
ABS =	Absorption Factor (unitless)	(Chemical Specific) g	(Chemical Specific) g
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * IRinh\_adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09 h	1.32E+09 h
IR_inh =	Inhalation Rate (m^3/day)	N/A	20 a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86 i	N/A
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.

b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} \quad \frac{100 \times (30-6)}{70}$$

$$= 114.29 \text{ (mg-year)/(kg-day)}$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 1574 \text{ } (cm^3\text{-year})/(kg)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc \times EDc}{BWc} + \frac{IR\_Inha \times (EDa - EDc)}{BWa} = \frac{15 \times 6}{15} \quad \frac{20 \times (30-6)}{70}$$

$$= 12.86 \text{ } (m^3\text{-year})/(kg\text{-day})$$

Surface Soil - Hypothetical Future On-Site Residential (Adult) Non-Carcinogenic Scenario

MSFC-045/046 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**Sfd**	**SFi**	**RME**	**DE**	**ABS**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MG/KG	Arsenic	A	1.50E+00	3.66E+00	1.51E+01	9.51E+00	4.10E-01	0.001	1.49E-05	2E-05	3.42E-08	1E-07	2.12E-10	3E-09
MG/KG	Cadmium	A				3.40E+02	2.00E-02	0.001	5.32E-04		1.22E-06		7.58E-09	
MG/KG	Copper	D				2.93E+01	3.00E-01	0.001	4.59E-05		1.05E-07		6.53E-10	
MG/KG	Nickel					5.70E+01	2.70E-01	0.001	8.93E-05		2.05E-07		1.27E-09	
	Total Risk									**2E-05**		**1E-07**		**3E-09**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk

Total Risk = 2E-05

Surface Soil - Hypothetical Future On-Site Residential (Adult) Non-Carcinogenic Scenario
MSFC-045/046 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Arsenic	A	3.00E-04	1.23E-04		9.51E+00	4.10E-01	0.001	1.30E-05	4E-02	6.38E-08	5E-04	3.29E-10	
MG/KG	Cadmium	A	1.00E+00	2.00E-02		3.40E+02	2.00E-02	0.001	4.66E-04	5E-04	2.28E-06	1E-04	1.18E-08	
MG/KG	Copper	D	4.00E-02	1.20E-02		2.93E+01	3.00E-01	0.001	4.01E-05	1E-03	1.97E-07	2E-05	1.02E-09	
MG/KG	Nickel		2.00E-02	5.40E-03		5.70E+01	2.70E-01	0.001	7.81E-05	4E-03	3.83E-07	7E-05	1.98E-09	
	Hazard Index									**5E-02**		**7E-04**		

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Total HI= 5E-02

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure Time (hours/day)	1.000	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal:

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical Specific)	f
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emisssion Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.
b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.
c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.
d = Particulate emission factor (PEF), adapted from U.S. EPA, Soil Screening Guidance: Technical Background Document, May 1996.
e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.
f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

Surface Soil - Hypothetical Future On-Site Residential (Adult) Non-Carcinogenic Scenario
MSFC-045/046 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	Chemical	WOE	RfDo	RfDd	RfDi	RME	DE	ABS	CDI	HQ	HGQ	HQ	CDI	HQ
MG/KG	Arsenic	A	3.00E-04	1.23E-04		9.51E+00	4.10E-01	0.001	1.22E-04	4E-01	1.44E-07	1E-03	1.15E-09	
MG/KG	Cadmium	A	1.00E+00	2.00E-02		3.40E+02	2.00E-02	0.001	4.35E-03	4E-03	5.15E-06	3E-04	4.12E-08	
MG/KG	Copper	D	4.00E-02	1.20E-02		2.93E+01	3.00E-01	0.001	3.75E-04	9E-03	4.43E-07	4E-05	3.55-09	
MG/KG	Nickel		2.00E-02	5.40E-03		5.70E+01	2.70E-01	0.001	7.29E-04	4E-02	8.63E-07	2E-04	6.92E-09	
	Hazard Index									**5E-01**		**2E-03**		
													Total HI=	**5E-01**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Appendix A
SFC-045/046–Surface soil
OU-9 Record of Decision

Station ID	Parameter	Conc	Q	Units	Comparison Criteria						Final Exceedance Y/N
					Background		Human Health				
							RBC		GWP		
SB09-006	Arsenic	1.20E+01	=	MG/KG	1.09E+01	X	2.31E-01	X	1.50E+01		Y
SB09-008	Chromium	1.39E+02	J	MG/KG	6.11E+01	X	2.47E+02		1.00E+01	X	Y
SB09-011	Chromium	8.60E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	Y
SB09-010	Chromium	8.05E+01	J	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	Y
SB09-014	Chromium	9.46E+02	=	MG/KG	6.11E+01		2.47E+02	X	1.00E+01	X	Y
SB09-014	Copper	7.02E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01	X	Y
SB09-014	Nickel	1.71E+02	J	MG/KG	1.72E+01		3.47E+03		2.10E+01	X	Y
SB09-012	1,1,1-Trichloroethane	2.00E-03	=	MG/KG			4.90E+00		9.00E-01		N
SB09-012	4,4x-DDE	2.90E-03	=	MG/KG			2.80E-01		5.50E+00		N
SB09-012	4,4x-DDT	2.20E-03	=	MG/KG			2.80E-01		3.00E-01		N
SB09-012	Acetone	7.50E-01	=	MG/KG			4.07E+02		8.00E+00		N
SB09-012	Aluminum	1.99E+04	=	MG/KG	3.07E+04						N
SB09-007	Arsenic	5.30E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-008	Arsenic	8.00E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-009	Arsenic	6.00E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-012	Arsenic	6.10E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-013	Arsenic	8.80E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-015	Arsenic	9.40E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-011	Arsenic	1.02E+01	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-010	Arsenic	6.70E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-010	Arsenic	6.60E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-014	Arsenic	4.60E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-012	Barium	1.43E+02	=	MG/KG	2.11E+02				3.20E+01	X	N
SB09-012	Beryllium	6.80E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+02		N
SB09-013	Beryllium	7.50E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+02		N
SB09-015	Beryllium	5.90E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+02		N
SB09-011	Beryllium	3.10E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+02		N
SB09-006	Beryllium	4.70E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+02		N
SB09-014	Beryllium	2.30E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+02		N
SB09-008	Cadmium	2.60E+00	=	MG/KG			1.74E+02				N
SB09-014	Cadmium	1.50E+01	=	MG/KG			1.74E+02				N
SB09-007	Cadmium	2.78E+01	J	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-009	Cadmium	4.17E+01	J	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-012	Cadmium	5.26E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-013	Cadmium	4.67E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-015	Cadmium	5.16E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-010	Cadmium	5.78E+01	J	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-006	Cadmium	3.91E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-012	Cobalt	1.17E+01	=	MG/KG	1.91E+01		1.05E+03		2.19E+02		N
SB09-007	Copper	9.80E+00	=	MG/KG	1.62E+01		6.42E+01		4.50E+01		N
SB09-008	Copper	2.53E+01	=	MG/KG	1.62E+01		6.42E+01		4.50E+01		N
SB09-009	Copper	1.01E+01	=	MG/KG	1.62E+01		6.42E+01		4.50E+01		N
SB09-012	Copper	9.00E+00	=	MG/KG	1.62E+01		6.42E+01		4.50E+01		N
SB09-013	Copper	8.40E+00	=	MG/KG	1.62E+01		6.42E+01		4.50E+01		N
SB09-015	Copper	1.28E+01	=	MG/KG	1.62E+01		6.42E+01		4.50E+01		N

Appendix A
MSFC-045/046–Surface soil
OU-9 Record of Decision

					Comparison Criteria						Final Exceedance
					Background		Human Health				
Station ID	Parameter	Conc	Q	Units			RBC		GWP		Y/N
SB09-011	Copper	6.50E+00	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-010	Copper	1.08E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-010	Copper	1.24E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-006	Copper	7.90E+00	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-008	Cyanide	6.70E-01	J	MG/KG	3.10E-01	X	3.47E+03		4.00E+01		N
SB09-011	Cyanide	4.40E-01	J	MG/KG	3.10E-01	X	3.47E+03		4.00E+01		N
SB09-012	Di-n-butyphthalate	4.70E-02	J	MG/KG			407E+02		1.20E+02		N
SB09-012	Iron	3.07E+04	=	MG/KG	3.93E+04						N
SB09-007	Lead	1.72E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-008	Lead	8.10E+00	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-009	Lead	2.09E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-012	Lead	2.33E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-013	Lead	1.40E+01	=	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-015	Lead	1.05E+01	=	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-011	Lead	7.80E+00	=	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-010	Lead	4.70E+00	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-010	Lead	1.84E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-006	Lead	2.24E+01	=	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-014	Lead	2.13E+01	=	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-012	Magnesium	5.56E+02	J	MG/KG	9.96E+02						N
SB09-012	Manganese	103E+01	=	MG/KG	2.30+03		1.49E+02		5.00E+00	X	N
SB09-007	Nickel	2.04E+03	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-008	Nickel	2.10E+01	=	MG/KG	1.72E+01	X	3.47E+03		2.10E+01		N
SB09-009	Nickel	1.11E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-012	Nickel	1.01E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-013	Nickel	9.70E+00	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-015	Nickel	1.11E+01	=	MG/KG	1.72E+01	X	3.47E+03		2.10E+01		N
SB09-011	Nickel	5.40E+00	J	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-010	Nickel	1.35E+01	=	MG/KG	1.21E+03						N
SB09-010	Nickel	1.79E+01	=	MG/KG			8.68E+02		1.83E+01		N
SB09-006	Nickel	6.60E+00	J	MG/KG	8.85E+01		1.22E+02				N
SB09-012	Potassium	6.01E+02	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-008	Silver	8.30E+00	J	MG/KG	8.62E+01	X	5.21E+04		4.20E+04		N
SB09-012	Vanadium	7.38E+01	=	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-007	Zinc	7.01E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-008	Zinc	9.76E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-009	Zinc	5.12E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-012	Zinc	4.30E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-013	Zinc	3.78E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-015	Zinc	5.84E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-011	Zinc	3.20E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-010	Zinc	5.27E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-010	Zinc	6.13E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-006	Zinc	4.08E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-014	Zinc	1.71E+02	J	MG/KG	8.62E+01	X	5.21E+04		4.20E+04		

MSFC-045/046 Residential Risk Assessment Calculations for Subsurface Soil

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Scenario

MSFC-045/046 OU-9 Record of Decision

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IRadj * FI * ET * EF * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
IR =	Ingestion Rate (mg/day)	N/A	100 a
IR_{adj} =	Age-Specific Ingestion Rate (mg - year)/(kg - day)	114.29 c	N/A
FI =	Fraction Ingested (unitless)	100%	100%
ET =	Exposure Time (days/year)	1.000 b	1.000 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * SAadj * AF * ABS * ET * EF * CF}{AT}$$

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	RME
SA =	Surface Area (cm^2)	N/A	2936 d
SA_{adj} =	Age-Specific Surface Area (cm^2)	1574 e	N/A
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1 f	1 f
ABS =	Absorption Factor (unitless)	(Chemical Specific) g	(Chemical Specific) g
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * IRinh\_adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	RME
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09 h	1.32E+09 h
IR_Inh =	Inhalation Rate (m^3/day)	N/A	20 a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86 i	N/A
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.

b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} + \frac{100 \times (30-6)}{70}$$

$$= 114.29 \text{ (mg-year)/(kg-day)}$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 1574 \text{ } (cm^3\text{-year})/(kg)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc \times EDc}{BWc} + \frac{IR\_Inha \times (EDa - EDc)}{BWa} = \frac{15 \times 6}{15} + \frac{20 \times (30-6)}{70}$$

$$= 12.86 \text{ } (m^3\text{-year})/(kg\text{-day})$$

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Non-carcinogenic Scenario
MSFC-045/046 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**SFd**	**SFi**	**RME**	**DE**	**ABS**	**CDI_{ajd}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MG/KG	Barium					1.62E+02	7.00E-02	0.001	2.54E-04		5.83E-07		3.61E-09	
MG/KG	Cadmium	B1			6.30E+00	1.07E+00	1.00E-02	0.001	1.68E-06		3.86E-09		2.39E-11	2E-10
MG/KG	Chromium	A				4.29E+02	2.00E-02	0.001	6.71E-04		1.54E-06		9.56E-09	
MG/KG	Copper	D				2.37E+01	3.00E-01	0.001	3.71E-05		8.52E-08		5.27E-10	
MG/KG	Manganese	D				7.84E+02	4.00E-02	0.001	1.23E-03		2.82E-06		1.75E-08	
MG/KG	Mercury	D				2.23E-01	1.00E-04	0.001	3.49E-07		8.03E-10		4.97E-12	
MG/KG	Nickel					1.78E+01	2.70E-01	0.001	2.79E-05		6.42E-08		3.98E-10	
MG/KG	Aroclor-1254	B2	2.00E+00	2.22E+00	2.00E+00	1.90E-02	9.00E-01	0.06	2.97E-08	6E-08	4.10E-09	9E-09	4.23E-13	8E-13
MG/KG	4,4'-DDD	B2	2.40E-01	3.43E-01		1.70E-03	7.00E-01	0.03	2.66E-09	6E-10	1.84E-10	6E-11	3.79E-14	
MG/KG	2-Butanone	D				8.00E-03	8.00E-01	0.01	1.25E-08		2.88E-10		1.78E-13	
MG/KG	Acetone	D				9.50E+00	8.30E-01	0.01	1.49E-05		3.42E-07		2.12E-10	
	Total Risk									**6E-08**		**9E-09**		**2E-10**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk

Total Risk = 7E-08

Subsurface Soil - Hypothetical Future On-Site Residential (Child) Non-carcinogenic Scenario
MSFC-045/046 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.62E+02	7.00E-02	0.001	2.07E-03	2.96E-02	1.47E-05	3.00E-03	1.18E-07	8.24E-04
MG/KG	Cadmium	B1	1.00E-03	1.00E-05		1.07E+00	1.00E-02	0.001	1.37E-05	1.37E-02	9.73E-08	9.73E-03	7.79E-10	
MG/KG	Chromium	A	1.00E+00	2.00E-02		4.29E+02	2.00E-02	0.001	5.48E-03	5.48E-03	3.89E-05	1.94E-03	3.11E-07	
MG/KG	Copper	D	4.00E-02	1.20E-02		2.37E+01	3.00E-01	0.001	3.03E-04	7.56E-03	2.15E-06	1.79E-04	1.72E-08	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-05	7.84E+02	4.00E-02	0.001	1.00E-02	7.16E-02	7.11E-05	1.27E-02	5.70E-07	3.99E-02
MG/KG	Mercury	D	3.00E-04	3.00E-08	8.57E-05	2.23E-01	1.00E-04	0.001	2.85E-06	9.51E-03	2.02E-08	6.74E-01	1.62E-10	1.89E-06
MG/KG	Nickel		2.00E-02	5.40E-03		1.78E+01	2.70E-01	0.001	2.28E-04	1.14E-02	1.62E-06	2.99E-04	1.30E-08	
MG/KG	Aroclor-1254	B2	2.00E-05	1.80E-05		1.90E-02	9.00E-01	0.06	2.43E-07	1.21E-02	1.03E-07	5.74E-03	1.38E-11	
MG/KG	4,4'-DDD	B2				1.70E-03	7.00E-01	0.03	2.17E-08		4.62E-09		1.23E-12	
MG/KG	2-Butanone	D	6.00E-01	4.80E-01	2.86E-01	8.00E-03	8.00E-01	0.01	1.02E-07	1.70E-07	7.25E-09	1.51E-08	5.81E-12	2.03E-11
MG/KG	Acetone	D	1.00E-01	8.30E-02		9.50E+00	8.30E-01	0.01	1.21E-04	1.21E-03	8.61E-06	1.04E-04	6.90E-09	
	Hazard Index									**1.62E-01**		**7.08E-01**		**4.07E-02**
													Total HI =	**9.11E-01**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure Time (4hours/24-hour day)	1.0	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical-Specific)	f
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25,1991.
b = Times spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.
c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.
d = Particulate emission factor (PEF), adapted from U.S. EPA, Soil Screening Guidance: Technical Background Document, May 1996.
e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.
f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

Subsurface Soil - Hypothetical Future On-Site Residential (Child) Non-carcinogenic Scenario
MSFC-045/046 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.62E+02	7.00E-02	0.001	2.22E-04	3E-03	1.09E-06	2E-04	5.62E-09	4E-05
MG/KG	Cadmium	B1	1.00E-03	1.00E-05		1.07E+00	1.00E-02	0.001	1.47E-06	1E-03	7.21E-09	7E-04	3.72E-11	
MG/KG	Chromium	A	1.00E+00	2.00E-02		4.29E+02	2.00E-02	0.001	5.87E-04	6E-04	2.88E-06	1E-04	1.49E-08	
MG/KG	Copper	D	4.00E-02	1.20E-02		2.37E+01	3.00E-01	0.001	3.24E-05	8E-04	1.59E-07	1E-05	8.20E-10	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-05	7.84E-02	4.00E-02	0.001	1.07E-03	8E-03	5.27E-06	9E-04	2.72E-08	2E-03
MG/KG	Mercury	D	3.00E-04	3.00E-08	8.57E-05	2.23E-041	1.00E-04	0.001	3.06E-07	1E-03	1.50E-09	5E-02	7.73E-12	9E-08
MG/KG	Nickel		2.00E-02	5.40E-03		1.78E+01	2.70E-01	0.001	2.44E-05	1E-03	1.20E-07	2E-05	6.18E-10	
MG/KG	Aroclor-1254	B2	2.00E-05	1.80E-05		1.90E-02	9.00E-01	0.06	2.60E-08	1E-03	7.66E-09	4E-04	6.59E-13	
MG/KG	4,4'-DDD	B2				1.70E-03	7.00E-01	0.03	2.33E-09		3.43E-10		5.89E-14	
MG/KG	2-Butanone	D	6.00E-01	4.80E-01	2.86E-01	8.00E-03	8.00E-01	0.01	1.10E-08	2E-08	5.37E-10	1E-09	2.77E-13	1E-12
MG/KG	Acetone	D	1.00E-01	8.30E-02		9.50E+00	8.30E-01	0.01	1.30E-05	1E-04	6.83E-07	8E-06	3.29E-10	
	Hazard Index									**2E-02**		**5E-02**		**2E-03**
Notes:	WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index												**Total HI =**	**7E-02**

Appendix A
MSFC-045/046—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-012	5	7	Acetone	1.40E+01	=	MG/KG			8.00E+00	X	Y
SB09-012	5	7	Acetone	9.50E+00	=	MG/KG			8.00E+00	X	Y
SB09-012	5	7	Barium	1.62E+02	=	MG/KG	6.07E+01	X	3.20E+01	X	Y
SB09-012	5	7	Barium	1.57E+02	=	MG/KG	6.07E+01	X	3.20E+01	X	Y
SB09-006	6	7	Chromium	1.14E+03	=	MG/KG	1.54E+02	X	1.00E+01	X	Y
SB09-006	6	7	Copper	5.84E+01	=	MG/KG	1.93E+01	X	4.50E+01	X	Y
SB09-012	5	7	Manganese	7.84E+02	=	MG/KG	4.90E+02	X	5.00E+00	X	Y
SB09-012	5	7	Manganese	1.14E+03	=	MG/KG	4.90E+02	X	5.00E+00	X	Y
SB09-010	5.5	6	Mercury	5.80E-01	=	MG/KG	1.93E-01	X	2.00E-01	X	Y
SB09-006	6	7	Nickel	2.94E+01	=	MG/KG	1.78E+01	X	2.10E01	X	Y
SB09-012	5	7	2-Butanone	8.00E-03	J	MG/KG					N/A
SB09-012	5	7	4,4'-DDD	1.70E-03	=	MG/KG					N/A
SB09-012	5	7	4,4'-DDD	1.60E-03	=	MG/KG					N/A
SB09-012	5	7	Aroclor-1254	1.90E-02	J	MG/KG					N/A
SB09-012	5	7	Aroclor-1254	1.10E-02	J	MG/KG					N/A
SB09-006	6	7	Cadmium	3.70E+00	=	MG/KG	1.57E+00	X			N/A
SB09-012	5	7	Potassium	9.50E+02	J	MG/KG	9.00E+02	X			N/A
SB09-012	5	7	1,1,1-Trichloroethane	8.00E-03	J	MG/KG			9.00E-01		N
SB09-012	5	7	4,4'-DDE	2.20E-03	=	MG/KG			5.50E+00		N
SB09-012	5	7	4,4'-DDE	2.60E-03	=	MG/KG			5.50E+00		N
SB09-012	5	7	Aluminum	2.58E+04	=	MG/KG	3.33E+04				N
SB09-012	5	7	Aluminum	2.50E+04	=	MG/KG	3.33E+04				N
SB09-015	4	6	Arsenic	1.09E+01	=	MG/KG	1.36E+01		1.50E+01		N
SB09-007	6	6.82	Arsenic	6.60E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-008	5	6	Arsenic	7.10E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-008	5	6	Arsenic	6.50E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-010	5.5	6	Arsenic	9.40E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-013	6	6.5	Arsenic	8.00E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-011	6	7	Arsenic	6.40E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-009	4	6	Arsenic	7.20E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-006	6	7	Arsenic	6.70E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-014	6	6.83	Arsenic	7.00E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-012	5	7	Arsenic	7.80E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-012	5	7	Arsenic	5.60E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-015	4	6	Beryllium	5.90E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-013	6	6.5	Beryllium	7.60E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-011	6	7	Beryllium	8.40E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-006	6	7	Beryllium	6.10E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-014	6	6.83	Beryllium	8.90E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-012	5	7	Beryllium	9.40E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-012	5	7	Beryllium	8.50E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-015	4	6	Chromium	5.72E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-007	6	6.82	Chromium	3.06E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-008	5	6	Chromium	3.55E+01	J	MG/KG	1.54E+02		1.00E+01	X	N

Appendix A
MSFC-045/046—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-009	5	6	Chromium	3.67E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-010	5.5	6	Chromium	3.25E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-013	6	6.5	Chromium	2.45E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-011	6	7	Chromium	2.53E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-009	4	6	Chromium	3.35E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-014	6	6.83	Chromium	2.26E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-012	5	7	Chromium	3.80E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-012	5	7	Chromium	4.02E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-012	5	7	Cobalt	1.57E+01	=	MG/KG	9.06E+00	X	2.19E+02		N
SB09-012	5	7	Cobalt	1.31E+01	=	MG/KG	9.06E+00	X	2.19E+02		N
SB09-015	4	6	Copper	1.44E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-007	6	6.82	Copper	1.29E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-008	5	6	Copper	9.40E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-008	5	6	Copper	1.11E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-010	5.5	6	Copper	1.18E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-013	6	6.5	Copper	7.90E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-011	6	7	Copper	8.90E00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-009	4	6	Copper	1.19E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-014	6	6.83	Copper	1.03E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-012	5	7	Copper	1.44E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-012	5	7	Copper	1.33E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-006	6	7	Cyanide	9.70E-01	J	MG/KG			4.00E+01		N
SB09-012	5	7	Di-n-butylphthalate	7.80E-02	J	MG/KG			1.20E+02		N
SB09-012	5	7	Di-n-butylphthalate	1.00E-01	J	MG/KG			1.20E+02		N
SB09-012	5	7	Iron	2.58E+04	=	MG/KG	6.86E+04				N
SB09-012	5	7	Iron	2.57E+04	=	MG/KG	6.86E+04				N
SB09-015	4	6	Lead	1.64E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-007	6	6.82	Lead	2.20E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-008	5	6	Lead	5.90E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-008	5	6	Lead	2.05E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-010	5.5	6	Lead	770E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-013	6	6.5	Lead	1.94E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-011	6	7	Lead	2.03E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-009	4	6	Lead	5.20E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-006	6	7	Lead	1.13E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-014	6	6.83	Lead	1.06E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-012	5	7	Lead	1.48E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-012	5	7	Lead	2.15E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-012	5	7	Magnesium	6.92E+02	J	MG/KG	7.45E+02				N
SB09-012	5	7	Magnesium	6.80E+02	J	MG/KG	7.45E+02				N
SB09-012	5	7	Methylene chloride	8.00E-03	J	MG/KG			1.00E-02		N
SB09-015	4	6	Nickel	1.36E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-007	6	6.82	Nickel	1.50E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-008	5	6	Nickel	1.05E+01	=	MG/KG	1.78E+01		2.10E+01		N

Appendix A
MSFC-045/046—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-008	5	6	Nickel	1.21E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-010	5.5	6	Nickel	1.43E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-013	6	6.5	Nickel	8.30E+00	J	MG/KG	1.78E+01		2.10E+01		N
SB09-011	6	7	Nickel	9.50E+00	J	MG/KG	1.78E+01		2.10E+01		N
SB09-009	4	6	Nickel	1.32E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-014	6	6.83	Nickel	9.60E+00	J	MG/KG	1.78E+01		2.10E+01		N
SB09-012	5	7	Nickel	1.60E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-012	5	7	Nickel	1.44E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-012	5	7	Potassium	8.21E+02	J	MG/KG	9.00E+02				N
SB09-012	5	7	Vanadium	6.30E+01	=	MG/KG	1.72E+02				N
SB09-012	5	7	Vanadium	6.14E+01	=	MG/KG	1.72E+02				N
SB09-015	4	6	Zinc	6.84E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-007	6	6.82	Zinc	5.93E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-008	5	6	Zinc	4.33E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-008	5	6	Zinc	5.44E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-010	5.5	6	Zinc	5.46E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-013	6	6.5	Zinc	3.37E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-011	6	7	Zinc	3.78E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-009	4	6	Zinc	5.20E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-006	6	7	Zinc	5.84E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-014	6	6.83	Zinc	4.05E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-012	5	7	Zinc	6.58E+01	J	MG/KG	1.17E+02		4.20E+04		
SB09-012	5	7	Zinc	6.15E+01	J	MG/KG	1.17E+02		4.20E+04		2

MSFC-047 Residential Risk Assessment Calculations for Surface Soil

Surface Soil - Hypothetical Future On-Site Residential (Adult) Scenario
MSFC-047 OU-9 Record of Decision

		Carcinogenic		Noncarcinogenic	
Ingestion:					
Age-specific intake (for carcinogenic compounds only):		Intake for non-carcinogenic compounds:			
$CDI_{adj} = \frac{Cs * IR_{adj} * FI * ET * EF * ED * CF}{AT}$		$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$			
Cs =	Concentration in soil (mg/kg)	RME		RME	
IR =	Ingestion Rate (mg/day)	N/A		100	a
Ir_{adj} =	Age-Specific Ingestion Rate (mg - year)(kg - day)	114.29	c	N/A	
FI =	Fraction Ingested (unitless)	100%		100%	
ET =	Exposure Time (hours/day)	1,000	b	1,000	b
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (year)	N/A		30	a
CF =	Conversion Factor (kg/mg)	1.00E-06		1.00E-06	
BW =	Body Weight (kg)	N/A		70	a
AT =	Averaging Time (days)	25550	a	10950	a
Dermal:					
Age-specific intake (for carcinogenic compounds only):					
$CDI_{adj} = \frac{Cs * IR_{adj} * FI * ET * EF * ED * CF}{AT}$		$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$			
Cs =	Concentration in soil (mg/kg)	RME		RME	
Sa =	Surface Area (cm^2)	N/A		2936	d
Sa_{adj} =	Age-Specific Surface Area (cm^2)	1574	e	N/A	
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	f	1	f
ABS =	Absorption Factor (unitless)	(Chemical Specific)	g	(Chemical Specific)	g
ET =	Exposure time (24 hours per 24-hour day)	0.167	b	0.167	b
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (day/year)	N/A		30	a
CF =	Conversion Factor (kg/mg)	1.00E-06		1.00E-06	
BW =	Body Weight (kg)	N/A		70	a
AT =	Averaging Time (days)	25550	a	10950	a
Inhalation:					
Age-specific intake (for carcinogenic compounds only):					
$CDI_{adj} = \frac{Cs * (1/PEF) * Irinh\ adj * ET * EF}{AT}$		$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$			
CS =	Concentration in soil (mg/kg)	RME		RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	h	1.32E+09	h
IR_Inh =	Inhalation Rate (m^3/day)	N/A		20	a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86	i	N/A	
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b	0.167	b
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (year)	N/A		30	a
BW =	Body Weight (kg)	N/A		70	a
AT =	Averaging Time (days)	25550	a	10950	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 991.

b = Times spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} + \frac{100 \times (30-6)}{70}$$

$$= 114.29\ (mg\text{-}year)(kg\text{-}day)$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 114.29\ (mg\text{-}year)(kg\text{-}day)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical=specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S. EPA Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$\frac{IR\_Inh\_adj = IR\_Inhc \times Edc}{BWc} + \frac{IR\_Inha \times (Eda - EDc)}{BWa} = \frac{15 \times 6}{15} + \frac{20 \times (30-6)}{70}$$

$$= 12.86\ (m3\text{-}year)\ (kg\text{-}day)$$

Surface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-047 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**SFd**	**Sfi**	**RME**	**DE**	**ABS**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MK/KG	Chromium	A				6.09E+01	2.00E-02	0.001	9.54E-05		2.19E-05		1.36E-09	
MG/KG	Nickel					1.59E+01	2.70E-01	0.001	2.49E-05		5.72E-08		3.54E-10	
MG/KG	Aroclor-1254	B2	2.00E+00	2.22E+00	2.00E+00	5.40E-02	9.00E-01	0.06	8.45E-08	2E-07	1.17E-8	3E-08	1.20E-12	2E-12
MG/KG	Aroclor-1260	B2	2.00E+00	2.22E+00	2.00E+00	4.00E-02	9.00E-01	0.06	6.26E-08	1E-07	8.64E-09	2E-08	8.91E-13	2E-12
	Total Risk									**3E-07**		**5E-08**		**4E-12**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk

Total Risk = **3E-07**

Surface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-047 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MK/KG	Chromium	A	1.00E+00	2.00E-02		6.09E+01	2.00E-02	0.001	8.34E-05	8E-05	4.09E-07	2E-05	2.11E-09	
MG/KG	Nickel		2.00E-02	5.40E-03		1.59E+01	2.70E+01	0.001	2.18E-05	1E-03	1.07E-07	2E-05	5.51E-10	
MG/KG	Aroclor-1254	B2	2.00E-05	1.80E-05		5.40E-02	9.00E-01	0.006	7.40E-08	4E-03	2.18E-08	1E-03	1.87E-12	
MG/KG	Aroclor-1260	B2				4.00E-02	9.00E-01	0.06	5.48E-08		1.61E-08		1.39E-12	
	Hazard Index									**5E-03**		**1E-03**		
Notes:	WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk												**Total HI=**	**6E-03**

Surface Soil - Hypothetical Future On-Site Residential (Adult) Scenario
MSFC-047 OU-9 Record of Decision

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure Time (4 hours per 24-hour day)	1.000	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal:

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical-Specific)	f
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: ?Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25,1991.

b = Times spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

d = Particulate emission factor (PEF), adapted from U.S. EPA, Soil Screening Guidance: Technical Background Document, May 1996.

e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

Surface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-047 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MK/KG	Chromium	A	1.00E+00	2.00E-02		6.09E+01	2.00E-02	0.001	7.79E-04	8E-04	9.22E-07	5E-05	7.39E-09	
MG/KG	Nickel		2.00E-02	5.40E-03		1.59E+01	2.70E-01	0.001	2.03E-04	1E-02	2.41E-07	4E-05	1.93E-09	
MG/KG	Aroclor-1254	B2	2.00E-05	1.80E-05		5.40E-02	9.00E-01	0.06	6.90E-07	3E-02	4.90E-08	3E-03	6.55E-12	
MG/KG	Aroclor-1260	B2				4.00E-02	9.00E-01	0.06	5.11E-07		3.63E-08		4.85E-12	
	Hazard Index									**5E-02**		**3E-03**		
													Total HI=	**5E-02**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Appendix A
MSFC-047—Surface Soil
OU-9 Record of Decision

Station ID	Parameter	Conc	Q	Units	Comparison Criteria						Final Exceedance Y/N
					Background		Human Health				
							RBC		GWP		
SB09-026	Aroclor-1254	5.40E-02	=	MG/KG			1.23E-02	X			Y
SB09-026	Aroclor-1260	4.00E-02	=	MG/KG			1.23E-02	X			Y
SB09-026	Chromium	1.00E+02	=	MG/KG	6.11E+01	X	2.47E+02		1.00E+01	X	Y
SB09-030	Nickel	2.12E+01	=	MG/KG	1.72E+01	X	3.47E+03		2.10E+01	X	Y
SB09-026	Nickel	2.11E+01	=	MG/KG	1.72E+01	X	3.47E+03		2.10E+01	X	Y
SB09-026	Aluminum	2.12E+04	=	MG/KG	3.07E+04						N
SB09-022	Antimony	2.90E+00	J	MG/KG	4.72E+00		6.85E+00				N
SB09-030	Arsenic	6.50E+00	=	MG/KG	1.90E+01		2.31E-01	X	1.50E+01		N
SB09-029	Arsenic	7.40E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01	X	N
SB09-028	Arsenic	7.40E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-027	Arsenic	7.30E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-027	Arsenic	6.60E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-025	Arsenic	7.70E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-024	Arsenic	7.00E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-023	Arsenic	5.70E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-022	Arsenic	6.70E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-026	Arsenic	6.50E+00	=	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-021	Arsenic	6.60E+00	J	MG/KG	1.09E+01		2.31E-01	X	1.50E+01		N
SB09-026	Barium	9.41E+01	=	MG/KG	2.11E+02				3.20E+01	X	N
SB09-026	Beryllium	4.60E-01	J	MG/KG	1.20E+00		9.47E-02	X	1.80E+02		N
SB09-026	Cadmium	9.20E-01	J	MG/KG			1.74E+02				N
SB09-030	Chromium	3.27E+01	J	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-029	Chromium	5.95E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-028	Chromium	3.84E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-027	Chromium	3.20E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-027	Chromium	3.16E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-025	Chromium	3.22E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-024	Chromium	5.99E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-023	Chromium	4.12E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-022	Chromium	3.96E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-021	Chromium	4.08E+01	=	MG/KG	6.11E+01		2.47E+02		1.00E+01	X	N
SB09-026	Cobalt	8.70E+00	J	MG/KG	1.91E+01		1.05E+03		2.19E+02		N
SB09-030	Copper	1.32E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-029	Copper	1.36E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-028	Copper	1.56E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-027	Copper	1.02E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-027	Copper	1.09E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-025	Copper	9.10E+00	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-024	Copper	1.30E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-023	Copper	1.07E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-022	Copper	9.60E+00	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-026	Copper	1.43E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-021	Copper	1.03E+01	=	MG/KG	1.62E+01		6.42E+03		4.50E+01		N
SB09-030	Cyanide	3.30E-01	=	MG/KG	3.10E-01	X	3.47E+03		4.00E+01		N
SB09-027	Cyanide	1.20E+00	J	MG/KG	3.10E-01	X	3.47E+03		4.00E+01		N

Appendix A
MSFC-047—Surface Soil
OU-9 Record of Decision

					Comparison Criteria						Final Exceedance Y/N
					Background		Human Health				
Station ID	Parameter	Conc	Q	Units			RBC		GWP		
SB09-026	Di-n-butylphthala										
SB09-026	Iron	3.13E+04	=	MG/KG	3.93E+04						N
SB09-030	Lead	4.20E+00	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-029	Lead	1.90E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-028	Lead	2.24E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-027	Lead	5.50E+00	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-027	Lead	2.10E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-025	Lead	2.01E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-024	Lead	2.07E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-023	Lead	1.72E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-022	Lead	2.31E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-026	Lead	1.89E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-021	Lead	2.31E+01	J	MG/KG	4.06E+01		4.00E+02		1.50E+00	X	N
SB09-026	Magnesium	5.37E+02	J	MG/KG	9.96E+02						N
SB09-026	Maganese	1.05E+03	=	MG/KG	2.30E+03		1.49E+02	X	5.00E+00	X	N
SB09-025	Mercury	1.80E-01	=	MG/KG	1.56E-01	X	5.21E+01		2.00E-01		N
SB09-024	Mercury	1.30E-01	=	MG/KG	1.56E-01		5.21E+01		2.00E-01		N
SB09-021	Mercury	1.10E-01	=	MG/KG	1.56E-01		5.21E-01		2.00E-01		N
SB09-029	Nickel	8.70E+00	J	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-028	Nickel	1.32E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-027	Nickel	1.06E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-027	Nickel	1.16E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-025	Nickel	8.80E+00	J	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-024	Nickel	1.27E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-023	Nickel	1.16E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-022	Nickel	8.40E+00	J	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-021	Nickel	1.01E+01	=	MG/KG	1.72E+01		3.47E+03		2.10E+01		N
SB09-026	Potassium	6.50E+02	J	MG/KG	1.21E+03						N
SB09-027	Selenium	4.40E-01	J	MG/KG			8.72E+01		3.00E+00		N
SB09-025	Selenium	6.00E-01	J	MG/KG			8.72E+01		3.00E+00		N
SB09-024	Selenium	3.50E-01	J	MG/KG			8.72E+01		3.00E+00		N
SB09-023	Selenium	3.50E-01	J	MG/KG			8.72E+01		3.00E+00		N
SB09-030	Silver	1.00E+00	J	MG/KG			8.68E+02		1.83E+01		N
SB09-026	Vanadium	7.39E+01	=	MG/KG	8.85E+01		1.22E+02				N
SB09-030	Zinc	6.73E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-029	Zinc	4.24E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-028	Zinc	5.06E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-027	Zinc	4.81E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-027	Zinc	5.32E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-025	Zinc	3.89E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-024	Zinc	3.92E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-023	Zinc	4.18E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-022	Zinc	3.95E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-026	zinc	5.39E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N
SB09-021	Zinc	3.89E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N

MSFC-047 Residential Risk Assessment Calculations for Subsurface Soil

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Scenario
MSFC-047 OU-9 Record of Decision

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure Time (4 hours per 24-hour day)	1.000	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal:

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical-Specific)	f
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: ?Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25,1991.

b = Times spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

d = Particulate emission factor (PEF), adapted from U.S. EPA, Soil Screening Guidance: Technical Background Document, May 1996.

e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Scenario
MSFC-047 OU-9 Record of Decision

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IR_{adj} * FI * ET * EF * ED * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME		RME	
IR =	Ingestion Rate (mg/day)	N/A		100	a
Ir_{adj} =	Age-Specific Ingestion Rate (mg - year)(kg - day)	114.29	c	N/A	
FI =	Fraction Ingested (unitless)	100%		100%	
ET =	Exposure Time (hours/day)	1,000	b	1,000	b
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (year)	N/A		30	a
CF =	Conversion Factor (kg/mg)	1.00E-06		1,00E-06	
BW =	Body Weight (kg)	N/A		70	a
AT =	Averaging Time (days)	25550	a	10950	a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IR_{adj} * FI * ET * EF * ED * CF}{AT}$$

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME		RME	
Sa =	Surface Area (cm^2)	N/A		2936	d
Sa_{adj} =	Age-Specific Surface Area (cm^2)	1574	e	N/A	
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	f	1	f
ABS =	Absorption Factor (unitless)	(Chemical Specific)	g	(Chemical Specific)	g
ET =	Exposure time (24 hours per 24-hour day)	0.167	b	0.167	b
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (day/year)	N/A		30	a
CF =	Conversion Factor (kg/mg)	1.00E-06		1.00E-06	
BW =	Body Weight (kg)	N/A		70	a
AT =	Averaging Time (days)	25550	a	10950	a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * Irinh\ adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

CS =	Concentration in soil (mg/kg)	RME		RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	h		
1.32E+09	h				
IR_Inh =	Inhalation Rate (m^3/day)	N/A		20	a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86	i	N/A	
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b	0.167	b
EF =	Exposure Frequency (day/year)	350	a	350	a
ED =	Exposure Duration (year)	N/A		30	a
BW =	Body Weight (kg)	N/A		70	a
AT =	Averaging Time (days)	25550	a	10950	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 991.

b = Times spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} + \frac{100 \times (30-6)}{70}$$

$$= 114.29\ (mg\text{-}year)(kg\text{-}day)$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 114.29\ (mg\text{-}year)(kg\text{-}day)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical=specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S. EPA Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc \times Edc}{BWc} + \frac{IR\_Inha \times (Eda - EDc)}{BWa} = \frac{15 \times 6}{15} + \frac{20 \times (30-6)}{70}$$

$$= 12.86\ (m3\text{-}year)\ (kg\text{-}day)$$

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario

MSFC-047 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**SFd**	**Sfi**	**RME**	**DE**	**ABS**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MG/KG	Barium					1.80E+02	7.00E-02	0.001	2.82E-04		6.48E-07		4.10E-09	
MG/KG	Manganese	D				1.87E+03	4.00E-02	0.001	2.93E-03		6.73E-06		4.17E-08	
MG/KG	4,4'-DDD	B2	2.40E-01	3.43E-01		1.50E-03	7.00E-01	0.03	2.35E-09	6E-10	1.62E-10	6E-11	3.34E-14	
	Total Risk									**6E-10**		**6E-11**		
Notes:	WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk										**Total Risk =**		**6E-10**	

Appendix A
MSFC-047—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-026	3	4	Barium	1.80E+02	=	MG/KG	6.07E+01	X	3.20E+01	X	Y
SB09-022	3.5	4	Chromium	2.74E+02	=	MG/KG	1.54E+02	X	1.00E+01	X	Y
SB09-026	3	4	Manganese	1.8E+03	=	MG/KG	4.90E+02	X	5.00E+00	X	Y
SB09-022	3.5	4	Nickel	5.19E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-026	3	4	4,4'=DDD	1.50E-03	J	MG/KG					N/A
SB09-022	3.5	4	Cadmium	6.80E+00	=	MG/KG	1.57E+00	X			N/A
SB09-026	3	4	4,4'-DDE	2.40E-03	=	MG/KG			5.50E+00		N
SB09-026	3	4	Aluminum	1.78E+04	=	MG/KG	3.33E+04				N
SB09-030	1.5	2	Arsenic	5.80E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-029	2.5	3	Arsenic	6.00E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-028	2.5	3	Arsenic	4.60E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-027	3	3.5	Arsenic	6.80E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-025	3.5	4	Arsenic	5.40E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-024	2.5	4	Arsenic	6.10E+01	J	MG/KG	1.36E+01		1.50E+01		N
SB09-023	3.5	4	Arsenic	5.30E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-026	3	4	Arsenic	5.40E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-021	4	4.5	Arsenic	6.00E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-022	3.5	4	Arsenic	6.50E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-022	3.5	4	Arsenic	7.80E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-026	3	4	Beryllium	9.40E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-030	1.5	2	Chromium	2.24E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-029	2.5	3	Chromium	2.05E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-028	2.5	3	Chromium	2.26E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-027	3	3.5	Chromium	2.14E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-025	3.5	4	Chromium	4.14E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-024	2.5	4	Chromium	2.22E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-023	3.5	4	Chromium	2.54E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-026	3	4	Chromium	2.37E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-021	4	4.5	Chromium	3.88E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-022	3.5	4	Chromium	7.07E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-026	3	4	Cobalt	1.21E+01	J	MG/KG	9.06E+00	X	2.19E+02		N
SB09-030	1.5	2	Copper	9.90E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-029	2.5	3	Copper	8.90E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-028	2.5	3	Copper	9.90E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-027	3	3.5	Copper	9.30E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-025	3.5	4	Copper	1.90E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-024	2.5	4	Copper	1.10E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-023	3.5	4	Copper	1.14E+01	=	MG/KG	1.93E+10		4.50E+01		N
SB09-026	3	4	Copper	1.04E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-021	4	4.5	Copper	9.80E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-022	3.5	4	Copper	1.22E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-022	3.5	4	Copper	3.77E+01	=	MG/KG	1.93E+01	X	4.50E+01		N
SB09-022	3.5	4	Cyanide	6.10E-01	J	MG/KG			4.00E+01		N
SB09-022	3.5	4	Cyanide	7.30E-01	J	MG/KG			4.00E+01		N

Appendix A
MSFC-047—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance
							Background		Human Health		
									GWP		Y/N
SB09-026	3	4	Iron	2.19E+04	=	MG/KG	6.86E+04				N
SB09-030	1.5	2	lead	2.11E+01	J	MG/KG	2.63E+01		1.50E+01	X	N
SB09-029	2.5	3	Lead	2.44E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-028	2.5	3	Lead	2.27E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-027	3	3.5	Lead	2.20E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-025	3.5	4	Lead	1.95E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-024	2.5	4	Lead	3.70E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-023	3.5	4	Lead	2.39E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-026	3	4	Lead	2.53E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-021	4	4.5	Lead	1.66E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-022	3.5	4	Lead	1.74E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-022	3.5	4	Lead	2.12E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-026	3	4	Magnesium	5.71E+02	J	MG/KG	7.45E+02				N
SB09-025	3.5	4	Mercury	1.20E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-022	3.5	4	Mercury	1.30E-01	=	MG/KG	1.93E-01		2.00E-01		N
SB09-030	1.5	2	Nickel	1.45E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-029	2.5	3	Nickel	1.20E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-028	2.5	3	Nickel	1.26E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-027	3	3.5	Nickel	1.12E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-025	3.5	4	Nickel	1.52E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-024	2.5	4	Nickel	1.19E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-023	3.5	4	Nickel	1.30E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-026	3	4	Nickel	1.24E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-021	4	4.5	Nickel	8.60E+00	J	MG/KG	1.78E+01		2.10E+01		N
SB09-022	3.5	4	Nickel	1.49E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-026	3	4	Potassium	5.71E+02	J	MG/KG	9.00E+02				N
SB09-029	2.5	3	Selenium	4.70E-01	J	MG/KG			3.00E+00		N
SB09-025	3.5	4	Selenium	3.60E-01	J	MG/KG			3.00E+00		N
SB09-024	2.5	4	Selenium	4.60E-01	J	MG/KG			3.00E+00		N
SB09-023	3.5	4	Selenium	6.10E-01	J	MG/KG			3.00E+00		N
SB09-026	3	4	Vanadium	4.79E+01	=	MG/KG	1.72E+02				N
SB09-030	1.5	2	Zinc	5.48E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-029	2.5	3	Zinc	4.56E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-028	2.5	3	Zinc	4.76E+01	J	MG/KG	1.17E+02		4.20E+-4		N
SB09-027	3	3.5	Zinc	4.48E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-025	3.5	4	Zinc	4.88E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-024	2.5	4	Zinc	4.44E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-023	3.5	4	Zinc	5.41E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-026	3	4	Zinc	4.64E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-021	4	4.5	Zinc	3.84E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-022	3.5	4	Zinc	4.52E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-022	3.5	4	Zinc	1.15E+02	J	MG/KG	1.17E+02		4.20E+04		N

Appendix A
MSFC-047—Subsurface Soil
OU-9 Record of Decision

Station ID	Parameter	Conc	Q	Units	Comparison Criteria						Final Exceedance Y/N
					Background		Human Health				
							RBC		GWP		
SB09-019	2-Butanone	1.00E-03	J	MG/K G			2.89E+02				N
SB09-019	Acetone	8.00E+00	=				4.07E+02		8.00E+00		N
SB09-019	Aluminum	1.99E+04	=		3.07E+04						N
SB09-018	Arsenic	7.10E+00	=		1.09E+01		2.31E-01	X	1.50E+01		N
SB09-020	Arsenic	7.70E+00	=		1.09E+01		2.31E-01	X	1.50E+01		N
SB09-016	Arsenic	6.80E+00	=		1.09E+01		2.31E-01	X	1.50E+01		N
SB09-017	Arsenic	5.50E+00	=		1.09E=01		2.31E-01	X	1.50E+01		N
SB09-019	Arsenic	6.20E+00	=		1.09E+01		2.31E-01	X	1.50E+01		N
SB09-019	barium	1.05E+02	=		2.11E+02				3.20E+01	X	N
SB09-019	Beryllium	5.30E-01	J		1.20E+00		9.47E-02	X	1.80E+02		N
SB09-018	Chromium	4.24E+01	J		6.11E+01		2.47E+02		1.00E+01	X	N
SB09-020	Chromium	4.53E+01	J		6.11E+01		2.47E+02		1.00E+01	X	N
SB09-016	Chromium	4.54E+01	J		6.11E+01		2.47E+02		1.00E+01	X	N
SB09-017	Chromium	5.62E+01	J		6.11E+01		2.47E+02		1.00E+01	X	N
SB09-019	Chromium	4.41E+01	=		6.11E+01		2.47E+02		1.00E+01	X	N
SB09-019	Cobalt	1.05E+01	J		1.91E+01		1.05E+03		2.19E+02		N
SB09-018	Copper	1.10E+01	=		1.62E+01		6.42E+03		4.50E+01		N
SB09-020	Copper	1.15E+01	=		1.62E+01		6.42E+03		4.50E+01		N
SB09-016	Copper	1.12E+01	=		1.62E+01		6.42E+03		4.50E+01		N
SB09-017	Copper	1.72E+01	=		1.62E+01	X	6.42E+03		4.50E+01		N
SB09-019	Copper	1.09E+01	=		1.62E+01		6.42E+03		4.50E+01		N
SB09-016	Cyanide	5.60E-01	J		3.10E-01	X	3.47E+03		4.00E+01		N
SB09-017	Cyanide	6.30E-01	J		3.10E-01	X	3.47E+03		4.00E+01		N
SB09-019	Di-n-butylphthalate	4.80E-02	J				4.07E+02		1.20E+02		N
SB09-019	Iron	3.03E+04	=		3.93E+04						N
SB09-018	Lead	2.27E+01	J		4.06E+01		4.00E+02		1.50E+00	X	N
SB09-020	Lead	4.30E+00	J		4.06E+01		4.00E+02		1.50E+00	X	N
SB09-016	Lead	1.94E+01	J		4.06E+01		4.00E+02		1.50E+00	X	N
SB09-017	Lead	4.10E+00	J		4.06E+01		4.00E+02		1.50E+00	X	N
SB09-019	Lead	2.07E+01	J		4.06E+01		4.00E+02		1.50E+00	X	N
SB09-019	Magnesium	5.37E+02	J		9.96E+02						N
SB09-019	Manganese	1.33E+03	=		2.30E+03		1.49E+02	X	5.00E+00	X	N
SB09-018	Nickel	1.26E+01	=		1.72E+01		3.47E+03		2.10E+01		N
SB09-020	Nickel	1.36E+01	=		1.72E+01		3.47E+03		2.10E+01		N
SB09-016	Nickel	8.50E+01	J		1.72E+01		3.47E+03		2.10E+01		N
SB09-017	Nickel	1.91E+01	=		1.72E+01	X	3.47E+03		2.10E+01		N
SB09-019	Nickel	1.15E+01	=		1.72E+01		3.47E+03		2.10E+01		N
SB09-019	Potassium	5.22E+02	J		1.21E+03						N
SB09-020	Silver	8.00E-01	J				8.68E+02		1.83E+01		N
SB09-016	Silver	4.30E+00	J				8.68E+02		1.83E+01		N
SB09-017	Silver	4.70E+00J					8.68E+02		1.83E+01		N
SB09-019	Vanadium	7.12E+01	=		8.85E+01		1.22E+02				N
SB09-018	Zinc	5.51E+01	J		8.62E+01		5.21E+04		4.20E+04		N
SB09-020	Zinc	6.01E+01	J		8.62E+01		5.21E+04		4.20E+04		N
SB09-016	Zinc	3.87E+01	J		8.62E+01		5.21E+04		4.20E+04		N
SB09-017	Zinc	8.39E+01	J		8.62E+01		5.21E+04		4.20E+04		N
SB09-019	Zinc	8.35E+01	J	MG/KG	8.62E+01		5.21E+04		4.20E+04		N

MSFC-048 Residential Risk Assessment Calculations for Subsurface Soil

Ingestion:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * IRadj * FI * ET * EF * CF}{AT}$$

Intake for non-carcinogenic compounds:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
IR =	Ingestion Rate (mg/day)	N/A	100 a
IR_{adj} =	Age-Specific Ingestion Rate (mg - year)/(kg - day)	114.29 c	N/A
FI =	Fraction Ingested (unitless)	100%	100%
ET =	Exposure Time (hours/day)	1.000 b	1.000 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Dermal:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * SAadj * AF * ABS * ET * EF * CF}{AT}$$

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
SA =	Surface Area (cm^2)	N/A	2936 d
SA_{adj}=	Age-Specific Surface Area (cm^2)	1574 e	N/A
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1 f	1 f
ABS =	Absorption Factor (unitless)	(Chemical Specific) g	(Chemical Specific) g
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
CF =	Conversion Factor (kg/mg)	1.00E-06	1.00E-06
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

Inhalation:

Age-specific intake (for carcinogenic compounds only):

$$CDI_{adj} = \frac{Cs * (1/PEF) * IRinh\_adj * ET * EF}{AT}$$

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

		Carcinogenic	Noncarcinogenic
Cs =	Concentration in soil (mg/kg)	RME	RME
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09 h	1.32E+09 h
IR_Inh =	Inhalation Rate (m^3/day)	N/A	20 a
IR_Inh_adj	Age-Specific Inhalation Rate (m^3/day)	12.86 i	N/A
ET =	Exposure Time (4 hours per 24-hour day)	0.167 b	0.167 b
EF =	Exposure Frequency (day/year)	350 a	350 a
ED =	Exposure Duration (year)	N/A	30 a
BW =	Body Weight (kg)	N/A	70 a
AT =	Averaging Time (days)	25550 a	10950 a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25, 1991.

b = Time spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.

c = Age-adjusted ingestion rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IRadj = \frac{IRc \times EDc}{BWc} + \frac{IRa \times (EDa - EDc)}{BWa} = \frac{200 \times 6}{15} + \frac{100 \times (30-6)}{70}$$

$$= 114.29 \text{ (mg-year)/(kg-day)}$$

d = Surface area of hands, 1/2 arms and feet of an adult for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.

e = Age-adjusted surface area for adults, adjusted for body weight and time for carcinogenic exposure.

$$SAadj = \frac{SAc \times EDc}{BWc} + \frac{SAa \times (EDa - EDc)}{BWa} = \frac{1418 \times 6}{15} + \frac{2936 \times (30-6)}{70}$$

$$= 1574 \text{ } (cm^3\text{-year})/(kg)$$

f = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.

g = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

h = Particulate emission factor (PEF), adapted from U.S.EPA, Soil Screening Guidance: Technical Background Document, May 1996.

i = Age-adjusted inhalation rate for adults, adjusted for body weight and time for carcinogenic exposure.

$$IR\_Inh\_adj = \frac{IR\_Inhc \times EDc}{BWc} + \frac{IR\_Inha \times (EDa - EDc)}{BWa} = \frac{15 \times 6}{15} + \frac{20 \times (30-6)}{70}$$

$$= 12.86 \text{ } (m^3\text{-year})/(kg\text{-day})$$

Surface Soil - Hypothetical Future On-Site Residential (Adult) Carcinogenic Scenario
MSFC-048 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**SFo**	**SFd**	**SFi**	**RME**	**DE**	**ABS**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**	**CDI_{adj}**	**ELCR**
MG/KG	Barium					1.91E+02	7.00E-02	0.001	2.99E-04		6.88E-07		4.25E-09	
MG/KG	Manganese	D				2.00E+03	4.00E-02	0.001	3.13E-03		7.20E-06		4.46E-08	
MG/KG	Chloromethane	C	1.30E-02	1.63E-02	6.00E-03	7.00E-03	8.00E-01	0.01	1.10E-08	1E-10	2.52E-10	4E-12	1.56E-13	9E-16
	Total Risk									**1E-10**		**4E-12**		**9E-16**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; ELCR = Excess Lifetime Cancer Risk

Total Risk = **1E-10**

Appendix A
MSFC-048—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-019	4.5	5.5	Barium	1.91E+02	=	MG/KG	6.07E+01	X	3.20E+01	X	Y
SB09-019	4.5	5.5	Manganese	2.00E+03	=	MG/KG	4.90+02	X	5.00E+00	X	Y
SB09-019	4.5	5.5	Chloromethane	7.00E-03	J	MG/KG					N/A
SB09-019	4.5	5.5	Acetone	6.60E+00	=	MG/KG			8.00E+00		N
SB09-019	4.5	5.5	Aluminum	1.91E+04	=	MG/KG	3.33E+04				N
SB09-018	5	5.5	Arsenic	5.60E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-020	5	5.5	Arsenic	5.20E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-016	5	6	Arsenic	7.30E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-016	5	6	Arsenic	7.10E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-017	5.5	6	Arsenic	5.80E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-019	4.5	5.5	Arsenic	5.40E+00	=	MG/KG	1.36E+01		1.50E+01		N
SB09-019	4.5	5.5	Beryllium	8.90E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-019	4.5	5.5	Bromomethane	1.50E-02	J	MG/KG			2.44E+00		N
SB09-018	5	5.5	Chromium	2.25E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-020	5	5.5	Chromium	2.64E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-016	5	6	Chromium	3.97E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-016	5	6	Chromium	3.56E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-017	5.5	6	Chromium	2.35E+01	J	MG/KG	1.54E+02		1.00E+01	X	N
SB09-019	4.5	5.5	Chromium	3.05E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-019	4.5	5.5	Cobalt	1.28E+01	=	MG/KG	9.06E+01	X	2.19E+02		N
SB09-018	5	5.5	Copper	1.29E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-020	5	5.5	Copper	1.24E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-016	5	6	Copper	1.59E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-016	5	6	Copper	1.47E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-017	5.5	6	Copper	1.21E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-019	4.5	5.5	Copper	1.10E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-019	4.5	5.5	Di-n-butylphthalate	4.90E-02	J	MG/KG			1.20E+02		N
SB09-019	4.5	5.5	Iron	2.50E+04	=	MG/KG	6.86E+04				N
SB09-018	5	5.5	Lead	2.46E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-020	5	5.5	Lead	1.97E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-016	5	6	Lead	4.70E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-016	5	6	Lead	4.60E+00	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-017	5.5	6	Lead	2.10E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-019	4.5	5.5	Lead	2.15E+01	J	MG/KG	2.63E+01		1.50E+00	X	N
SB09-019	4.5	5.5	Magnesium	5.69E+02	J	MG/KG	7.45E+02				N
SB09-019	4.5	5.5	Methylene Chloride	7.00E-03	J	MG/KG			1.00E-02		N
SB09-018	5	5.5	Nickel	1.62E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-020	5	5.5	Nickel	1.31E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-016	5	6	Nickel	1.89E+01	=	MG/KG	1.78E+01	X	2.10E+01		N
SB09-016	5	6	Nickel	1.59E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-017	5.5	6	Nickel	1.35E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-019	4.5	5.5	Nickel	1.28E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-019	4.5	5.5	Potassium	7.19E+02	J	MG/KG	9.00E+02				N
SB09-016	5	6	Silver	7.30E-01	J	MG/KG	1.17E+00		1.83E+01		N

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-019	4.5	5.5	Vanadium	5.69E+01	=	MG/KG	1.72E+02				N
SB09-018	5	5.5	Zinc	6.04E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-020	5	5.5	Zinc	5.23E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-016	5	6	Zinc	8.22E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-016	5	6	Zinc	6.90E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-017	5.5	6	Zinc	4.94E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-019	4.5	5.5	Zinc	4.70E+01	J	MG/KG	1.17E+02		4.20E+04		N

Appendix A
MSFC-049/050—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-055	12	18	Barium	1.64E+02	J	MG/KG	6.07E+01	X	3.20E+01	X	Y
SB09-055	12	18	Lead	2.77E+01	=	MG/KG	2.63E+01	X	1.50E+00	X	Y
SB09-055	12	18	Manganese	1.87E+03	=	MG/KG	4.90E+02	X	5.00E+00	X	Y
SB09-060	10	12	Nickel	2.34E+01	=	MG/KG	1.78E+01	X	2.10E+01	X	Y
SB09-056	9	11	Aluminum	2.66E+04	=	MG/KG	3.33E+04				N
SB09-057	11	13	Aluminum	2.45E+04	=	MG/KG	3.33E+04				N
SB09-060	10	12	Aluminum	2.91E+04	=	MG/KG	3.33E+04				N
SB09-060	10	12	Aluminum	2.23E+04	=	MG/KG	3.33E+04				N
SB09-058	11	13	Aluminum	2.20E+04	=	MG/KG	3.33E+04				N
SB09-059	13	15	Aluminum	2.17E+04	=	MG/KG	3.33E+04				N
SB09-053	8	10	Aluminum	2.95E+04	=	MG/KG	3.33E+04				N
SB09-053	8	10	Aluminum	2.16E+04	=	MG/KG	3.33E+04				N
SB09-051	7	9	Aluminum	2.71E+04	=	MG/KG	3.33E+04				N
SB09-052	9	11	Aluminum	2.47E+04	=	MG/KG	3.33E+04				N
SB09-055	12	18	Aluminum	2.22E+04	=	MG/KG	3.33E+04				N
SB09-054	9	11	Aluminum	3.12E+04	=	MG/KG	3.33E+04				N
SB09-060	10	12	Antimony	3.00E+00	J	MG/KG	8.00E+00				N
SB09-054	9	11	Antimony	3.20E+00	J	MG/KG	8.00E+00				N
SB09-056	9	11	Arsenic	6.20E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-057	11	13	Arsenic	6.40E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-060	10	12	Arsenic	6.10E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-060	10	12	Arsenic	6.60E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-058	11	13	Arsenic	5.80E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-059	13	15	Arsenic	4.70E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-053	8	10	Arsenic	6.00E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-053	8	10	Arsenic	7.00E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-051	7	9	Arsenic	6.40E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-052	9	11	Arsenic	6.40E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-055	12	18	Arsenic	5.30E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-054	9	11	Arsenic	7.40E+00	J	MG/KG	1.36E+01		1.50E+01		N
SB09-056	9	11	Beryllium	8.70E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-057	11	13	Beryllium	8.30E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-060	10	12	Beryllium	7.80E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-060	10	12	Beryllium	7.00E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-058	11	13	Beryllium	8.30E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-059	13	15	Beryllium	1.00E+00	J	MG/KG	1.26E+00		1.80E+02		N
SB09-053	8	10	Beryllium	1.00E+00	J	MG/KG	1.26E+00		1.80E+02		N
SB09-053	8	10	Beryllium	7.20E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-051	7	9	Beryllium	9.20E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-052	9	11	Beryllium	9.50E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-055	12	18	Beryllium	7.20E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-054	9	11	Beryllium	9.90E-01	J	MG/KG	1.26E+00		1.80E+02		N
SB09-056	9	11	Cadmium	1.30E+00	=	MG/KG	1.57E+00				N
SB09-057	11	13	Cadmium	7.60E-01	=	MG/KG	1.57E+00				N

Appendix A
MSFC-049/050—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-060	10	12	Cadmium	3.80E-01	J	MG/KG	1.57E+00				N
SB09-053	8	10	Cadmium	5.60E-01	J	MG/KG	1.57E+00				N
SB09-054	9	11	Cadmium	4.30E-01	J	MG/KG	1.57E+00				N
SB09-055	12	18	Calcium	9.58E+02	=	MG/KG	1.20E+03				N
SB09-056	9	11	Chromium	3.34E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-057	11	13	Chromium	3.05E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-060	10	12	Chromium	3.45E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-060	10	12	Chromium	1.54E+02	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-058	11	13	Chromium	2.60E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-059	13	15	Chromium	2.30E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-053	8	10	Chromium	2.64E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-053	8	10	Chromium	5.43E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-051	7	9	Chromium	3.04E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-052	9	11	Chromium	2.81E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-055	12	18	Chromium	3.22E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-054	9	11	Chromium	3.84E+01	=	MG/KG	1.54E+02		1.00E+01	X	N
SB09-055	12	18	Cobalt	9.20E+00	=	MG/KG	9.06E+00	X	2.19E+02		N
SB09-056	9	11	Copper	1.21E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-057	11	13	Copper	1.09E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-060	10	12	Copper	1.20E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-060	10	12	Copper	1.04E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-058	11	13	Copper	1.00E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-059	13	15	Copper	9.80E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-053	8	10	Copper	1.39E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-053	8	10	Copper	1.21E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-051	7	9	Copper	1.27E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-052	9	11	Copper	1.14E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-055	12	18	Copper	9.80E+00	=	MG/KG	1.93E+01		4.50E+01		N
SB09-054	9	11	Copper	1.40E+01	=	MG/KG	1.93E+01		4.50E+01		N
SB09-056	9	11	Iron	2.17E+04	=	MG/KG	6.86E+04				N
SB09-057	11	13	Iron	2.28E+04	=	MG/KG	6.86E+04				N
SB09-060	10	12	Iron	2.12E+04	=	MG/KG	6.86E+04				N
SB09-060	10	12	Iron	2.28E+04	=	MG/KG	6.86E+04				N
SB09-058	11	13	Iron	2.04E+04	=	MG/KG	6.86E+04				N
SB09-059	13	15	Iron	1.40E+04	=	MG/KG	6.86E+04				N
SB09-053	8	10	Iron	2.21E+04	=	MG/KG	6.86E+04				N
SB09-053	8	10	Iron	2.60E+04	=	MG/KG	6.86E+04				N
SB09-051	7	9	Iron	2.60E+04	=	MG/KG	6.86E+04				N
SB09-052	9	11	Iron	2.53E+04	=	MG/KG	6.86E+04				N
SB09-055	12	18	Iron	1.88E+04	=	MG/KG	6.86E+04				N
SB09-054	9	11	Iron	2.04E+04	=	MG/KG	6.86E+04				N
SB09-056	9	11	Lead	1.93E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-057	11	13	Lead	1.98E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-060	10	12	Lead	2.19E+01	=	MG/KG	2.63E+01		1.50E+00	X	N

Appendix A
MSFC-049/050—Subsurface Soil
OU-9 Record of Decision

Station ID	Upper Depth	Lower Depth	Parameter	Conc	Q	Units	Comparison Criteria				Final Exceedance Y/N
							Background		Human Health		
									GWP		
SB09-060	10	12	Lead	1.87E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-058	11	13	Lead	2.01E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-059	13	15	Lead	2.07E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-053	8	10	Lead	2.06E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-053	8	10	Lead	2.06E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-051	7	9	Lead	1.86E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-052	9	11	Lead	2.10E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-054	9	11	Lead	2.12E+01	=	MG/KG	2.63E+01		1.50E+00	X	N
SB09-055	12	18	Magnesium	6.45E+02	J	MG/KG	7.45E+02				N
SB09-056	9	11	Nickel	1.63E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-057	11	13	Nickel	1.46E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-060	10	12	Nickel	1.60E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-058	11	13	Nickel	1.50E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-059	13	15	Nickel	1.33E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-053	8	10	Nickel	1.79E+01	=	MG/KG	1.78E+01	X	2.10E+01		N
SB09-053	8	10	Nickel	1.46E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-051	7	9	Nickel	1.60E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-052	9	11	Nickel	1.42E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-055	12	18	Nickel	1.31E+01	=	MG/KG	1.78E+01		2.10E+01		N
SB09-054	9	11	Nickel	2.04E+01	=	MG/KG	1.78E+01	X	2.10E+01		N
SB09-055	12	18	Potassium	7.48E+02	J	MG/KG	9.00E+02				N
SB09-053	8	10	Silver	1.10E+00	J	MG/KG	1.17E+00		1.83E+01		N
SB09-055	12	18	Sodium	1.05E+02	J	MG/KG			2.00E+03		N
SB09-056	9	11	Thallium	8.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-060	10	12	Thallium	9.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-058	11	13	Thallium	8.00E-02	J	MG/KG	6.30E-01		4.00E-01		N
SB09-059	13	15	Thallium	2.70E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-053	8	10	Thallium	1.10E+01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-053	8	10	Thallium	14.40E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-055	12	18	Thallium	2.90E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-054	9	11	Thallium	1.10E-01	J	MG/KG	6.30E-01		4.00E-01		N
SB09-055	12	18	Vanadium	4.42E+01	=	MG/KG	1.72E+02				N
SB09-056	9	11	Zinc	5.52E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-060	10	12	Zinc	6.12E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-053	8	10	Zinc	5.89E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-053	8	10	Zinc	5.31E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-051	7	9	Zinc	6.08E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-052	9	11	Zinc	5.24E+01	J	MG/KG	1.17E+02		4.20E+04		N
SB09-054	9	11	Zinc	7.37E+01	J	MG/KG	1.17E+02		4.20E+04		N

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Non-carcinogenic Scenario
MSFC-048 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.91E+02	7.00E-02	0.001	2.62E-04	4E-03	1.28E-06	3E-04	6.62E-09	5E-05
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-04	2.00E+03	4.00E-02	0.001	2.74E-03	2E-02	1.34E-05	2E-04	69.93E-08	5E-03
MG/KG	Chloromethane	C				7.00E-03	8.00E-01	0.01	9.59E-09		4.70E-10		2.43E-13	
	Hazard Index									**2E-02**		**3E-03**		**5E-03**
Notes:	WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index												**Total HI=**	**3E-02**

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure time (hours/day)	1.000	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical-Specific)	f
ET =	Exposure Time (4 hours per 24-hour day)	0.164	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25,1991.
b = Times spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.
c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.
d = Particulate emission factor (PEF), adapted from U.S. EPA, Soil Screening Guidance: Technical Background Document, May 1996.
e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.
f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1991)

Subsurface Soil - Hypothetical Future On-Site Residential (Child) Non-carcinogenic Scenario
MSFC-048 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.91E+02	7.00E-02	0.001	2.44E-06	3E-02	2.89E-06	6E-04	2.32E-08	2E-04
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-04	2.00E+03	4.00E-02	0.001	2.56E-05	2E-01	3.03E-05	5E-03	2.43E-07	2E-02
MG/KG	Chloromethane	C				7.00E-03	8.00E-01	0.01	8.95E-09		1.06E-09		8.49E-13	
	Hazard Index									**2E-01**		**6E-03**		**2E-02**
Notes:	WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index												**Total HI=**	**2E-01**

MSFC-049/050 Residential Risk Assessment Calculations for Subsurface Soil

Subsurface Soil - Hypothetical Future On-Site Residential (Child) Non-carcinogenic Scenario
MSFC-049/050 OU-9 Record of Decision

									Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.64E+02	7.00E-02	0.001	2.10E-03	3E-02	2.48E-06	5E-04	1.99E-08	1E-04
MG/KG	Lead	B2				2.25E+01	1.50E-01	0.001	2.88E-04		3.41E-07		2.73E-09	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-04	1.87E+03	4.00E-02	0.001	2.39E-02	2E-01	2.83E-05	5E-03	2.27E-07	2E-02
MG/KG	Nickel		2.00E-02	5.40E-03		1.85E+01	2.70E-01	0.001	2.36E-04	1E-02	2.80E-07	5E-03	2.24E-09	
	Hazard Index									**2E-01**		**6E-03**		**2E-02**
													Total HI=	**2E-01**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

Ingestion:

$$CDI = \frac{Cs * IR * FI * ET * EF * ED * CF}{BW * AT}$$

		Noncarcinogenic	
Cs =	Concentration in soil (mg/kg)	RME	
IR =	Ingestion Rate (mg/day)	200	a
FI =	Fraction Ingested (unitless)	100%	
ET =	Exposure Time (hours/day)	1.000	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Dermal:

$$CDI = \frac{Cs * SA * AF * ABS * ET * EF * ED * CF}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
SA =	Surface Area (cm^2)	1418	c
AF =	Soil-Skin Adherence Factor (mg/cm^2)	1	e
ABS =	Absorption Factor (unitless)	(Chemical-Specific)	f
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
CF =	Conversion Factor (kg/mg)	1.00E-06	
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

Inhalation:

$$CDI = \frac{Cs * (1/PEF) * IR * ET * EF * ED}{BW * AT}$$

Cs =	Concentration in soil (mg/kg)	RME	
PEF =	Particulate Emission Factor (m^3/kg)	1.32E+09	d
IR =	Inhalation Rate (m^3/day)	15	a
ET =	Exposure Time (4 hours per 24-hour day)	0.167	b
EF =	Exposure Frequency (day/year)	350	a
ED =	Exposure Duration (year)	6	a
BW =	Body Weight (kg)	15	a
AT =	Averaging Time (days)	2190	a

References:

a = U.S. EPA, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," OSWER Directive 9285.6-03, March 25,1991.
b = Times spent outdoors in the contaminated areas using best professional judgement, based on the nature of the activity per NASA 1997 workplan.
c = Surface area of hands, 1/2 arms and feet of a child for exposure to soils, adapted from CEHT, Technical Report: Soil Cleanup Target Levels for FDEP, September 2, 1997.
d = Particulate emission factor (PEF), adapted from U.S. EPA, Soil Screening Guidance: Technical Background Document, May 1996.
e = U.S. EPA Dermal Exposure Assessment: Principles and Application, January 1992.
f = Chemical-specific absorption factors are found in Table 8.4 & Appendix C of the MSFC OU-9 Remedial Investigation Report (August 1999)

Subsurface Soil - Hypothetical Future On-Site Residential (Adult) Non-carcinogenic Scenario
MSFC-049/050 OU-9 Record of Decision

										Ingestion		Dermal		Inhalation	
Units	**Chemical**	**WOE**	**RfDo**	**RfDd**	**RfDi**	**RME**	**DE**	**ABS**	**CDI**	**HQ**	**CDI**	**HQ**	**CDI**	**HQ**
MG/KG	Barium		7.00E-02	4.90E-03	1.43E-04	1.64E+02	7.00E-02	0.001	2.25E-04	3E-03	1.10E-06	2E-04	5.68E-09	4E-05
MG/KG	Lead	B2				2.25E+01	1.50E-01	0.001	3.08E-05		1.51E-07		7.80E-10	
MG/KG	Manganese	D	1.40E-01	5.60E-03	1.43E-05	1.87E+03	4.00E-02	0.001	2.56E-03	2E-02	1.26E-05	2E-03	6.48E-08	5E-03
MG/KG	Nickel		2.00E-02	5.40E-03		1.85E+01	2.70E-01	0.001	2.53E-05	1E-03	1.24E-07	2E-05	6.40E-10	
	Hazard Index									**2E-02**		**2E-03**		**5E-03**
													Total HI=	**3E-02**

Notes: WOE = Weight of Evidence; CDI = Chronic Daily Intake; RME = Reasonable Maximum Exposure Concentration; HQ = Hazard Quotient; HI = Hazard Index

APPENDIX B

Residential Risk Assessment for OU-9

Introduction

A baseline risk evaluation was performed for the sites grouped under Operable Unit (OU)-9 for the No Further Action (NFA) report, to evaluate the status of the sites for an unlimited future land use possibility. The risk assessment (RA) followed by the standard four-step process, which includes:

- Hazard identification/selection of chemicals of potential concern (COPCs)
- Exposure assessment
- Toxicity assessment
- Risk characterization

These four components of the RA were evaluated following Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) procedures and using the U.S. Environmental Protection Agency's (EPA's) *Risk Assessment Guidance* (RAGs) *for Superfund* (1989). The sites included in OU-9 are considered for potential unlimited future land use; therefore, only a residential scenario was evaluated. This scenario is intended to conservatively estimate the cancer risks and noncancer hazards from each of the sites. The RA for OU-9 evaluated soil and groundwater data from MSFC-044, MSFC-045/046, MSFC-047, MSFC-048, MSFC-049/050, and MSFC-A.

Hazard Identification/COPC Selection

The soil (surface and subsurface) data are collected to evaluate the contamination conditions that lead to an NFA recommendation were evaluated in the RA. Also, the groundwater monitoring well data from the current Resource Conservation and Recovery Act (RCRA) sampling events were used. Soil data from each site were evaluated separately. Groundwater data were evaluated on an OU-wide basis. All of the detected inorganic chemicals were compared with background values for the respective media. The inorganic chemicals detected above background and the detected organic chemicals were compared to risk-based concentrations (RBCs). The RBCs are the EPA Region III values (EPA Region III RBC Table, April 1998) calculated at a 10^{-6} risk level for carcinogens and a 0.1 hazard quotient (HO) for noncarcinogens. COPCs were selected based on the sites' history. Those COPCs exceeding the RBCs were selected as COPCs for risk assessment evaluation. Table B-1 lists the COPCs quantitatively evaluated in the RA.

TABLE B-1
List of Chemicals of Potential Concern (COPCs) for Risk Assessment Evaluation for Soil and Groundwater at OU-9
OU-9 Record of Decision

Surface Soil	Subsurface Soil	Groundwater
Arsenic	Arsenic	Iron
Chromium	Barium	Manganese
Copper	Cadmium	
Mercury	Chromium	
Nickel	Copper	
Aroclor-1254	Manganese	
Aroclor-1260	Mercury	
	Nickel	
	Aroclor-1254	
	44DDD	
	Acetone	
	2-Butanone	
	Chloromethane	

Magnesium, lead, and sodium exceeded comparison criteria in groundwater, but are not included as COPCs. Magnesium was detected in groundwater above background concentrations to background, with a few exceptions. However, a toxicity factor, which is necessary for risk/HI calculations, is not available. There are no MCL, SMCL, or health-advisory values for magnesium. Additionally, this naturally occurring inorganic chemical is common in the media and is a nutritionally essential element. Thus, not including it as a COPC is not important for human health protection, specifically because observed concentrations could be from natural minerals. Lead also does not have a toxicity factor. Although the total lead level was reported to be above the background concentration and the action level based-MCL in the second quarter 1998, the same well was reported to be below detection limits in the third quarter 1998 and the fourth quarter 1997. Thus, the reported concentration could be an anomalous result. This assumption is based on the fact that lead was not detected above the background concentration in soils or in any other wells in the area, and in the same well during other monitoring periods before or after this one reported detection. Sodium is an essential nutrient and does not have a toxicity factor.

All the surface and subsurface soil samples collected from the different sites were used for the selection of COPCs.

Groundwater monitoring wells included for this risk evaluation are the wells located within the site boundary or downgradient of the Industrial Waste Treatment Facility (IWTF). These include Wells MSFC-021R, 22R, 25, 26, 29D, 32, 33D, 34D, 38, 39, 47D, 49, and 51D (see Figure 1-14). The quarterly monitoring data collected from 4th quarter 1997 to 3rd quarter 1998 were used for this risk analysis. There were no organic chemicals detected at concentrations above the RBCs in any of the wells. One of the wells within the IWTF, MSFC-021R, is the only well where trace levels of cis-1,2-dichloroethene were detected, and only in the 4th quarter 1997. Cis1,2-Dichloroethene has not been detected since then, and the detected concentration was below a health-based concentration. Thus, the groundwater does not have any organic constituents of potential concern. Additionally, there were no carcinogenic chemicals detected above background levels.

The inorganic chemicals, iron and manganese, are the only chemicals detected above both the background concentrations and a health-based concentration level. These are therefore, the only COPCs for groundwater. These chemicals are distributed in groundwater across MSFC at similar concentrations as those observed in the wells at this IWTF site.

Exposure Assessment

The overall objective of the exposure assessment is to characterize the potential for exposure to site-related COPCs to a future hypothetical resident. The results of the exposure assessment are represented as a chronic daily intakes (CDIs) for carcinogenic or noncarcinogenic endpoints specific to each COPC and receptor identified at each of the sites within OU-9.

This OU is located at the intersection of Martin Road and Tiros Street. Martin Road is on the south, Tiros Street is on the east, and a shallow drainage area separates the site from a wooded area on the north and sloping land on the west, which is bounded by branches to Indian Creek. Three of the sites are capped and the OU is no longer being used as the IWTF. The OU is located within the industrial area of MSFC, at the property boundary to Redstone Arsenal (RSA). There is no steady industrial activity within the site. Martin Road is a heavily used access road. There are no office or residential buildings in the vicinity of the site. The closest residential areas are beyond the RSA property along the Martin Road, at least one mile from the site. Indian Creek flows from north to south along the boundary between RSA and MSFC, within the proximity of OU-9.

The site surface soils are covered with clean soils within the old IWTF area. The location of the site within the highly industrial area and adjacent to public access roads makes it undesirable for future residential use. The site groundwater currently is not in use, and it is unlikely to be used for potable purposes in the future. Much of the site's shallow groundwater is likely to release to the downgradient stream and wetlands (possibly springs). At the Alabama Department of Environmental Management's (ADEM's) request, a conservative human health evaluation was performed using a future hypothetical residential receptor exposure scenario for exposures to soils and grounbdwater.

Exposure factors for surface soils, subsurface soils, and groundwater are included in Table B-2. For the most part, the exposure assumptions or parameter values used in the dose calculations reflect default "upperbound" or reasonable maximum exposure (RME) conditions.

Quantification of Exposure

This subsection includes the exposure point concentrations and dose estimation algorithms for the exposure scenarios identified previously. The estimated doses will be compared with the toxicity factors identified in the toxicity assessment (next subsection) to calculate risks and Hqs in the risk characterization section.

Exposure Point Concentrations

Exposure estimates were derived for each COPC on a media- and receptor-specific basis for both carcinogenic risk and noncarcinogenic hazard estimation purposes.

The soil and groundwater samples evaluated in the RA were discussed in the COPC selection subsection. The exposure point concentrations (EPCs) for soils are the RME concentrations, the upper confidence limit (UCL) at the 95th percentile on the mean (UCL 95 percent).The EPCs for OU-9 groundwater are the average of all detected concentrations for COPCs. The multiple quarters' data are averaged for each well. A summary of the results is included in Table B-3.

Intake Estimates

The intake (dose) estimates were calculated for each of the complete exposure pathways. These estimates are described as follows.

Exposure Assumptions and General Characteristics–Default Residential Scenario

A future residential scenario (including an adult and a child) was evaluated using EPA recommended default exposure factors. The values of the exposure factors were presented in Table B-2. Further details on the exposure factors are included in Appendix B of the *MSFC Surface Media Report* (October 1998). For carcinogenic risk estimation intakes, age-adjusted exposure factors were used for ingestion, dermal, and inhalation pathways.

The results of the quantitative dose estimates, along with the risk calculations, are included in this appendix.

Toxicity Assessment

The toxicity values obtained from EPA sources for the soil and groundwater COPCs are presented in Table B-4. There were no carcinogenic COPCs in site groundwater.

Risk Characterization

The risk characterization discusses the quantitative and qualitative evaluation of potential risks associated with COPCs detected in soil and groundwater at the OU-9 sites.

Excess lifetime carcinogenic risk (ELCR), defined as the unitless upperbound probability of the individual receptor developing cancer over a lifetime under the specified exposure conditions, is derive for each carcinogenic COPC as follows:

ELCR = CDI * CSF

Where:

CDI = Route- and media-specific cumulative daily intake (dose) of a COPC (mg/kg/day)

CSF = Route-specific cancer slope factor $(mg/kg/day)^{-1}$ for the COPC

TABLE B-2
Exposure Factors Used for the Residential Soil and Groundwater Exposure Scenarios
OU-9 Record of Decision

Symbols	Parameter	Residential (Adult)	Residential (Child)
BW	Body Weight (kg)[a]	70	15
AT_C	Averaging Time - Carcinogenic (days)[a]	70x365	N/A
AT-NC	Averaging Time - Noncarcinogenic (days)[a]	30x365	6x365
IR_Ing_s	Soil Incidental Ingestion Rate (mg/day)[b]	100	200
$IR\_adj\_Ing_s$	Age-adjusted Soil Incidental Rate (mg-year/kg-day)[a]	114.29	*
IR_Ing_{gw}	Groundwater Ingestion Rate (L/day)[b]	2	1
$IR\_adj\_Ing_{gw}$	Age-adjusted Groundwater Ingestion Rate (L-day/kg-day)[a]	1.1	*
SA_s	Skin Surface Area for Soil Exposure (cm^2)[b]	2936	1418
SA_adj_s	Age-adjusted Skin Surface Area for Soil Exposure ((cm^2-year/kg)[a]	1574	*
SA_{gw}	Skin Surface Area for Groundwater Exposure (cm^2)[b]	18150	6880
SA_adj_{gw}	Age-adjusted Skin Surface Area for Groundwater Exposure (cm^2-year/kg)[b]	10638	*
AF	Adherence Factor (mg/cm^2)[d]	1	1
IR_Inh	Inhalation Factor (m^3/day)[a]	20	15
IR_adj_Inh	Age-adjusted inhalation Rate (m^3-year/kg-day)[a]	12.86	*
PEF	Particulate Emission Factor (m^3/kg)[c]	1.32E+09	1.32E+09
ET_s	Exposure Time for Soil Exposure (hours/day)[b]	4	4
ET_{gw}	Exposure Time for Groundwater Exposure (hyours/day)[b]	0.25	0.25
EF	Exposure Frequency (days/year)[b]	350	350
ED	Exposure Duration (years)[a]	30	6

Notes:

a EPA Risk Assessment Guidance for Superfund, Vol. I : Human Health Evaluation Manual (Part A), Interim Final, December 1989.

b see Intake assumptions tables in Appendix B for details

c Adapted from EPA1996, soil Screening Guidance: Technical Background Document

d Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment, Interim, November 1995.

N/A Not applicable for this receptor

* Age-adjusted factors do not apply to this scenario

TABLE B-3
Exposure Point Concentrations for Sites in OU-9
OU-9 Record of Decision

Site	Medium	Constituent	Mean (mg/kg or kg/L[1])	Max (mg/kg or mg/L[1])	EPC (mg/kg)
MSFC-044	SB	Arsenic	11.0	19.2	12.9
		Cadmium	0.5	2.5	0.85
		Lead	14.9	29.2	17.5
		Manganese	491.0	540.0	540.0
		Mercury	0.09	0.54	0.14
		Nickel	33.9	71.2	48.6
MSFC-045/046	SS	Arsenic	7.7	12.0	9.5
		Chromium	148.8	946.0	340.0
		Copper	17.1	70.2	29.3
		Nickel	27.0	171.0	57.0
MSFC-045/046	SB	Barium	162.0	162.0	162.0
		Cadmium	0.6	3.7	1.1
		Chromium	171.0	1410.0	428.8
		Copper	16.0	58.4	23.7
		Manganese	784.0	784.0	784.0
		Mercury	0.10	0.58	0.22
		Nickel	13.9	29.4	17.8
		Aroclor-1254	0.02	0.02	0.02
		4,4'-DDD	0.002	0.002	0.002
		2-Butanone	0.01	0.01	0.01
		Acetone	9.5	9.5	9.5
MSFC-047	SS	Chromium	47.6	100.0	60.9
		Nickel	12.6	21.2	15.9
		Aroclor-1254	0.05	0.05	0.05
		Aroclor-1260	0.04	0.04	0.04
MSFC-047	SB	Barium	180.0	180.0	180.0
		Manganese	1870.0	1870.0	1870.0
		4,4'-DDD	0.002	0.002	0.002
MSFC-048	SB	Barium	191.0	191.0	191.0
		Manganese	2000.0	2000.0	2000.0
		Chloromethane	0.01	0.01	0.01
MSFC-049/050	SB	Barium	164.0	164.0	164.0
		Lead	21.1	27.7	22.5
		Manganese	1870.0	1870.0	1870.0
		Nickel	16.4	23.4	18.5
MSFC-A	SS	Mercury	0.11	0.22	0.22
MSFC-A	SB	Barium	129.0	129.0	129.0
		Cadmium	1.1	4.4	4.4
		Chromium	78.7	186.0	186.0

TABLE B-3
Exposure Point Concentration for Sites in OU-9
OU-9 Record of Decision

Site	Medium	Constituent	Mean (mg/kg or kg/L[1])	Max (mg/kg or mg/L[1])	EPC (mg/kg)
MSFC-A (cont'd)		Manganese	2130.0	2130.0	2130.0
		Nickel	20.7	49.3	49.3
		Aroclor-1254	0.02	0.02	0.02
		2-Butanone	0.01	0.01	0.01
		Acetone	11.0	11.0	11.0
OU-9	GW	Iron	2.36	32.3	2.36
		Manganese	1.97	58.3	1.97

[1] Soil units are mg/kg, and groundwater units are mg/L
GW–Groundwater
SS–Surface soil
SB–Subsurface soil
EPC–Exposure point concentration

TABLE B-4
Toxicity Criteria for Chemicals of Potential Concern (COPCs)
OU-9 Record of Decision

Chemical Name	Oral SF (kg-day/mg)	Source	Chronic Oral RfD (kg-day/mg)	Source	UF	Inhalation SF (kg-day/mg)	Source	Chronic Inhalation RfD mg/kg-day)	Source	UF
Arsenic	1.50E+00	I	3.00E-04	I	3	1.51E+01	I			
Barium			7.00E-02	I	3			1.43E-04	A	1000
Cadmium			5.00E-04	I	10	6.30E+00	I	5.71E-05	W	
Chromium III			1.00E-00	I						
Copper			4.00E-02	E						
Lead										
Manganese			2.30E-02	I	1			1.43E-05	I	1000
Mercury			3.00E-04	H	30			8.57E-05	I	30
Nickel			2.00E-02	I	300					
Aroclor-1254	2.00E+00	I(PCB)	2.00E-05	I	300					
Aroclor-1260	2.00E+00	I(PCB)								

Notes:
SF - (Cancer) Slope Factor
RfD - (Noncancer) Reference Dose
A - Health Effects Assessment Summary Tables (HEAST) alternate method; (EPA, 1997).
E - EPA-NCEA Regional Support provisional value.
H - Health Effects Assessment Summary Tables (HEAST); (EPA, 1997).
I - Integrated Risk Information System (IRIS); (IRIS, 1997).
I(PCB) - High risk and persistence value used, (IRIS, 1997)
UF - Uncertainty Factor
W - Withdrawn from IRIS or HEAST

Summing all of the route- and media-specific ELCR estimates provides a total ELCR for a given COPC for each receptor. The summation of total ELCRs for all of the COPCs provides the total ELCR for the receptor.

Likewise, the upperbound noncarcinogenic health hazard is estimated initially by calculating HQs on a route- and media-specific basis for each COPC for receptor, as follows:

$$HQ = CDI/RfD$$

where:

CDI = Route- and media-specific cumulative daily intake (dose) of a COPC (mg/kg/day)

RfD = Route-specific reference dose (mg/kg/day) (daily intake considered unlikely to cause adverse affects over a lifetime of exposure) for the COPC

Summing the route- and media-specific HQs provides an estimate of a total hazard index (HI) for a given COPC for each receptor. The summation of HIs across COPCs provides a total HI for the receptor. This procedure ignores toxicological endpoints and mechanisms of action as the basis for estimating the noncarcinogenic hazard from multi-contaminant exposure, thus resulting in a highly conservative estimate of potential effects.

For scenarios resulting in noncarcinogenic hazards above a value of 1.0, individual target organs for each of the COPCs were identified and the HI was summed by target organ, to identify if any individual target organ hazard is above a value of 1.0.

For the purposes of regulatory decision-making at contaminated sites, EPA uses an acceptable risk range of 10^{-4} to 10^{-6}. Typically, results falling within or below this range are considered a reasonable basis for NFA, depending on the degree of conservatism and uncertainty associated with like estimates. Likewise, a total HI of 1.0 or less is considered evidence of *de minimus* potential for noncarcinogenic health effects. Conservatism and uncertainties inherent in the analyses are considered when interpreting the results.

The results of the carcinogenic risk and noncarcinogenic hazard calculations are provided on a media-, receptor-, and route-specific basis for each pathway identified in the exposure assessment section in Appendix C of the *MSFC Surface Media RI Report* (October 1998). Cancer risks and noncancer HIs are summarized in Table B-5.

Future Hypothetical Resident-Soil Risk Assessment Results

The total ELCR to hypothetical future onsite adult and child residents was estimated for each site. The total risks were within the 10^{-4} to 10^{-6} levels. All the sites were below 10^{-6}, except SFC-044 and MSFC-0454/046. The noncarcinogenic HI for soils was below 1.0 for all the sites evaluated.

TABLE B-5
Carcinogenic Risk and Noncarcinogenic HI Estimation by Site–OU-9
OU-9 Record of Decision

Site	Receptor	Media	Exposure Route	Risk	Hazard Index
MSFC-044	**Adult Resident**	Surface Soil	Ingestion	n/a	n/a
			Dermal	n/a	n/a
			Inhalation	n/a	n/a
		Subsurface Soil	Ingestion	3E-05	0.07
			Dermal	2E-07	0.03
			Inhalation	4E-09	0.001
			Total	**3E-05**	**0.1**
	Child Resident	Surface Soil	Ingestion	n/a	n/a
			Dermal	n/a	n/a
			Inhalation	n/a	n/a
		Subsurface Soil	Ingestion	n/a	n/a
			Dermal	n/a	0.07
			Inhalation	n/a	0.005
			Total		**0.7**
	NOTE:	**No Surface Soil data available in database**			
MSFC-045/046	**Adult Resident**	Surface Soil	Ingestion	2E-05	0.05
			Dermal	1E-07	0.0007
			Inhalation	3E-09	n/a
				2E-05	**0.05**
		Subsurface Soil	Ingestion	6E-08	0.002
			Dermal	9E-09	0.05
			Inhalation	2E-10	0.002
				7E-08	**0.07**
			Total	**2E-05**	**0.1**
	Child Resident	Surface Soil	Ingestion	n/a	0.5
			Dermal	n/a	0.002
			Inhalation	n/a	n/a
					0.5
		Subsurface Soil	Ingestion	n/a	**0.20**
			Dermal	n/a	**0.03**
			Inhalation	n/a	**0.09**
					0.33
			Total		**0.83**
MSFC-047	**Adult Resident**	Surface Soil	Ingestion	3E-07	0.005
			Dermal	5E-08	0.001
			Inhalation	4E-12	n/a
				3E-07	**0.006**
		Subsurface Soil	Ingestion	6E-10	0.02

TABLE B-5
Carcinogenic Risk and Noncarcinogenic HI Estimation by Site–OU-9
OU-9 Record of Decision

Site	Receptor	Media	Exposure Route	Risk	Hazard Index
			Dermal	6E-11	0.01
			Inhalation	n/a	0.03
				6E-10	**0.06**
			Total	**3E-07**	**0.07**
	Child Resident	Surface Soil	Ingestion	n/a	0.05
			Dermal	n/a	0.003
			Inhalation	n/a	n/a
					0.5
		Subsurface Soil	Ingestion	n/a	**0.16**
			Dermal	n/a	**0.71**
			Inhalation	n/a	**0.04**
					0.91
			Total		**0.95**
MSFC-048	**Adult Resident**	Surface Soil	Ingestion	n/a	n/a
			Dermal	n/a	n/a
			Inhalation	n/a	n/a
		Subsurface Soil	Ingestion	1E-10	0.02
			Dermal	4E-12	0.003
			Inhalation	9E-16	0.005
			Total	**1E-10**	**0.03**
	Child Resident	Surface Soil	Ingestion	n/a	n/a
			Dermal	n/a	n/a
			Inhalation	n/a	n/a
MSFC-048		Subsurface Soil	Ingestion	n/a	0.2
			Dermal	n/a	0.006
			Inhalation	n/a	0.02
			Total		**0.2**
	NOTE:	**No COPCs available from Surface Soil data**			
MSFC-049/-50	**Adult Resident**	Surface Soil	Ingestion	n/a	n/a
			Dermal	n/a	n/a
			Inhalation	n/a	n/a
		Subsurface Soil	Ingestion	n/a	0.02
			Dermal	n/a	0.002
			Inhalation	n/a	0.005
			Total		**0.02**
	Child Resident	Surface Soil	Ingestion	n/a	n/a
			Dermal	n/a	n/a
			Inhalation	n/a	n/a

TABLE B-5
Carcinogenic Risk and Noncarcinogenic HI Estimation by Site–OU-9
OU-9 Record of Decision

Site	Receptor	Media	Exposure Route	Risk	Hazard Index
		Subsurface Soil	Ingestion	n/a	0.2
			Dermal	n/a	0.006
			Inhalation	n/a	0.02
			Total		**0.2**
	NOTE:	**No Surface Soil data available in database**			
MSFC-A	**Adult Resident**	Surface Soil	Ingestion	n/a	0.001
			Dermal	n/a	0.05
			Inhalation	n/a	0.00000009
					0.5
		Subsurface Soil	Ingestion	6E-08	0.03
			Dermal	1E-08	0.006
			Inhalation	6E-10	0.005
				7E-08	**0.05**
			Total	**7E-08**	**0.1**
	Child Resident	Surface Soil	Ingestion	n/a	0.009
			Dermal	n/a	0.1
			Inhalation	n/a	0.0000003
					0.1
		Subsurface Soil	Ingestion	n/a	0.32
			Dermal	n/a	0.085
			Inhalation	n/a	0.11
					0.51
			Total	**n/a**	**0.6**
Groundwater	**Adult Resident**		Ingestion	n/a	0.6
			Dermal	n/a	0.03
			Inhalation	n/a	n/a
			Total		**0.6**
	Child Resident		Ingestion	n/a	1.4
			Dermal	n/a	0.04
			Inhalation	n/a	n/a
			Total		**1.4**

Notes
n/a–not applicable, no COPCs
Cancer risks were evaluated for age-adjusted lifetime exposure and were included in summary for adult resident.

The MSFC-044 data are from subsurface soils; there are no COPCs for the surface soil. Assumption used for the subsurface soil exposure scenario are highly conservative, because if subsurface soils are excavated and become exposed, they are likely to have lower concentrations due to mixing. In addition, the subsurface soil does not pose risks beyond those due to naturally occurring arsenic levels. Arsenic is detected at a maximum concentration of 19.2 milligrams per kilogram (mg/kg), which is similar to the background

subsurface soil concentration for arsenic of 13.6 mg/kg. The EPC for arsenic (UCL 95 percent) is 12.9 mg/kg, which is below background level. Thus, the MSFC-044 potential risks are below the background risk levels.

Similarly, MSFC-045/046 risks estimated at $2x10^{-5}$, are again from arsenic detected in surface soil samples. The maximum observed arsenic is at 12mg/kg, compared to a surface soil background value of 10.9 mg/kg. The EPC (UC: 95 percent) value for arsenic is estimated at 9.51 mg/kg, which is below the background level. Thus, the total site risks are below the background levels.

Thus, the overall site risks under the most conservative risk estimation scenario are within the acceptable limits and below the background levels. Therefore, the site soils do not present a human health risk concern under existing conditions and potential future use.

Future Hypothetical Resident–Groundwater Risk Assessment Results

The groundwater at the OU is under a routine monitoring program under RCRA. Site groundwater is mostly free of organic contamination. There were no carcinogenic chemicals detected above background in the groundwater. Thus, only a noncarcinogenic HI was estimated for an adult and a child. The total HI from the average observed iron and manganese concentration was 0.6 for an adult, which is below the value of 1.0, and 1.4 for a child, which is slightly above a value of 1.0. Both iron and manganese are nutritionally essential for human metabolism.

Health-based Evaluation for Lead

Lead is addressed separately, because there are no toxicity criteria available for quantitative risk estimations for this metal. Lead was detected at concentrations below background at most of the sites (MSFC-045/046, MSFC-047, MSFC-048, MSFC-A). The maximum observed lead concentration in MSFC-044 subsurface soils of 29.2 mg/kg was above background concentrations, but below a residential health protection-based screening concentration of 400 mg/kg. Lead was detected in groundwater in one out of 78 samples during the 2nd quarter 1998 sample, and there was no detectable level of dissolves lead ever reported in any of the wells. Thus, this reported groundwater lead detection appears to be an anomaly. Therefore, lead is not an issue in soils at any of the sites within OU-9 or in the regional groundwater.

Sources of Uncertainty. Potential sources of uncertainty exist in each of the steps in this risk assessment. The uncertainty associated with the COPC selection process comes from the sample location, number of samples, time variation in the sampling events, differences in sample analysis by different labs, etc.

The site data were intended for NFA documentation, and the sites in general are free of contamination, as can be noted from this conservative risk assessment. Uncertainty in the data evaluation for the COPC selection results from the use of a single value for the background. The site concentration ranges and the background concentration ranges could be similar. This may result in selection of several of the naturally occurring chemicals as COPCs, using the maximum detected concentration for comparison with the background value. Groundwater data are based on multiple rounds of monitoring, which reduces the uncertainty. However, due to the similar inorganic chemical concentration levels over time,

their occurrence could be due to the type of hydrogeology at the screening depths for each of the monitoring wells, rather than due to the presence of IWTF-related contributions.

Exposure assumptions used in this RA are not applicable to the OU, because the OU is not suitable for residential use. Such a scenario was evaluated to present the absolute worst-case possible exposures. Use of groundwater at the OU is not occurring and is not anticipated in the future, due to location within an industrial area next to roadways. Another source of uncertainty is the assumption of direct exposure to the subsurface soils at or near the maximum concentrations. There is no possibility for direct exposure to the subsurface soil concentrations without significant disturbance and possibly diluted concentrations. Due to the small size of each individual site, a limited number of samples were available, resulting in an EPC default to maximum detected concentrations. This introduces a high conservatism into the risk estimations.

The toxicity factors used for arsenic are developed based on studies of drinking water contamination. Arsenic present in soil is less bioavailable; thus, the cancer slope factor for arsenic is conservative when applied to soil. The slope factor for chromium is based on studies on chromium metal plating workers' exposure to chronic acid fumes with hexavalent chromium. Thus, the chromium inhalation factor is not relevant to environmental soil chromium. The groundwater COPCs are naturally occurring, and nutritionally essential for normal functioning of the human body.

Most of the estimated risks are from the naturally occurring chemicals, like arsenic, at concentrations similar to or below background. Thus risks are below the background levels.

Conclusions

- The residential risk assessment calculations assumed that the existing fence would be removed and that both surface and subsurface soil are accessible for direct exposure to future residents which is a highly conservative assumption.

- Site soils do not present risks above background levels.

- Groundwater at the OU has inorganic naturally occurring chemicals only. Only two of them are above background and health-based levels.

- No carcinogenic chemicals were detected above the screening criteria and therefore, no carcinogenic chemicals were identified as CO(PCs in the groundwater. The HI from iron and manganese is 0.6 for adults and 1.4 for children, which are both within the 1.0 level.

- Overall, none of the sites within OU-9 present significant risks or HIs.